ELEMENTARY SCIENCE

For VIII Class

S. A. ALEEM & SONS. 13, Hospital Road, Lahore
FOR
PUNJAB TEXTBOOK BOARD, LAHORE

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ELEMENTARY SCIENCE
FOR
CLASS VIII

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(FOR ENGLISH-MEDIUM SCHOOLS)

Published by :

S. A. ALEEM & SONS

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PUNJAB TEXTBOOK BOARD
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Elementary Science

For

Class VIII

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PREFACE

The amazing progress made by science and technology during the last twenty or twenty five years has not only made a deep impact on our way of living but has also brought about changes of far-reaching importance in man's way of thinking. These changes have resulted in modifying our method of teaching science. In the beginning of the century the teaching of science was considered to be imparting information about facts of natural phenomena, but due to the rapid advances made by science subjects it is now considered important that stress should be laid on making the children grasp the fundamental concepts which have been the cause of countless discoveries. Now science is regarded as not only a well-organised branch of knowledge but as means used by scientists for solving new problems.

The revolutionary changes brought about in various branches of science have made the educationists realize the necessity of modernising the science syllabi in schools, colleges and universities so that they may be in consonance with the new approach towards the scientific realities of modern age. For this reason in 1967 the Government of West Pakistan planned to modernize the syllabi of science and mathematics in schools and colleges. New syllabi and textbooks for higher secondary classes were introduced in 1967, for secondary classes in 1968 and for B.A. and B. Sc. classes in 1969. It was further decided that syllabi for middle classes should also be modernized with effect from the beginning of educational year 1971. The Education Extension Centre, Lahore called a series of meetings of the Advisory committee consisting of representative teachers of all regions of West Pakistan and science syllabi for classes VI, VII and VIII were prepared. This book has been prepared for class VIII in accordance with the modernized syllabus.

Experimental editions of science books for classes VI and VII were published in 1971 and 1972-respectively. The student-editions of both these books were printed after thorough revision based on the suggestions given by the working teachers who attended training courses at the Education Extension Centre Lahore. The first edition of this book was also of experimental nature which was tried out during the refresher course for teacher's trainers held in the Education Extension Centre and then during training courses for teachers held at thirty selected schools throughout Punjab. This book is now published for students of class VIII after improving it in the light of suggestions given by teachers. With the publication of this book the 3-year project of modernization of science books for elementary classes has been completed successfully.

In compiling this book an attempt has been made that all the fundamental concepts may be deduced experimentally in easy language to suit the mental level of the children. As far as possible the diagrams have been given for elucidation.

It is hoped that this book will be a help in realising the aim for which the syllabus has been modernized.

The Editors.

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I

Human Body and Health

1.1. Systems of Organs in the Body

On Eid-ul-Azha you might have seen the meat of slaughtered animals being cut and cleaned. You must have observed that in the body of every animal there are a large number of organs *e.g.*, they have intestines, blood vessels, nerves, bones, brain, heart and lungs which are situated at their fixed places and perform their own particular functions. On close observation these organs, appear to be forming a few systems *e.g.*, the gullet;stomach and intestine will appear to be forming one system. Heart, arteries and veins will be forming a separate net-work and brain, spinal cord and nerves are joined together to form a separate system.

No system of the body is separate from the other. Heart and arteries cannot do any useful work without the lungs and if the muscles get separated from the heart and blood, they would become useless. It is only for the sake of understanding that these systems are described separately. In fact all the organs of the body co-ordinate with one another and work together.

1.2 Digestive System

This is a system into which food is taken and digested. Generally this system is like a tube which starts from the mouth and goes down to the anus. This tube becomes narrow at certain place and wider at others and there are some ducts which pour the juices from the liver and pancreas, into it.

The digestive system starts from the mouth between the lips. The mouth leads back into the buccal cavity which is the name of the empty space between the palate, tongue and cheeks. In addition to the mouth the passage from the nose also opens into the buccal cavity by passing above the palate.

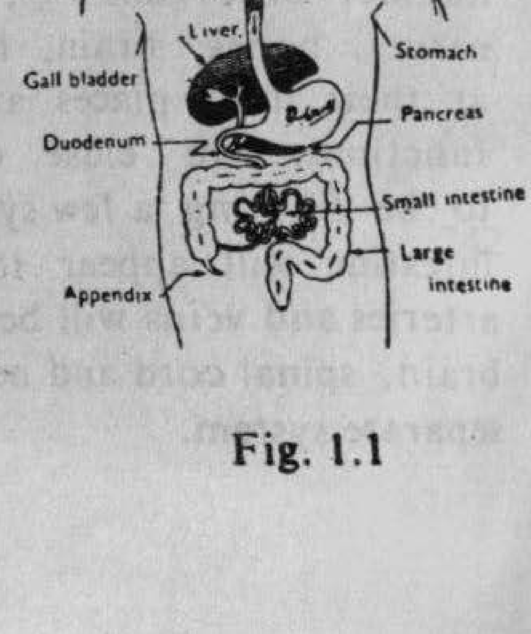

Mouth cavity
Respiratory tube
ہوا کی نالی
Oesophagus
Liver
Stomach
معدہ
Gall bladder
Pancreas
Duodenum
Small intestine
Large intestine
Appendix

Fig. 1.1

Inside the buccal cavity there are teeth which are fixed in the right and left jaws. The function of teeth is to cut the food and make it fine and soft. In this function the saliva also helps which is secreted by the glands present around the buccal cavity. The main function of the saliva is to lubricate the food and help it in passing down the throat but it also helps to digest the carbohydrates in the food. The tongue moves the food on all sides in the buccal cavity so that the saliva may mix up with the food thoroughly.

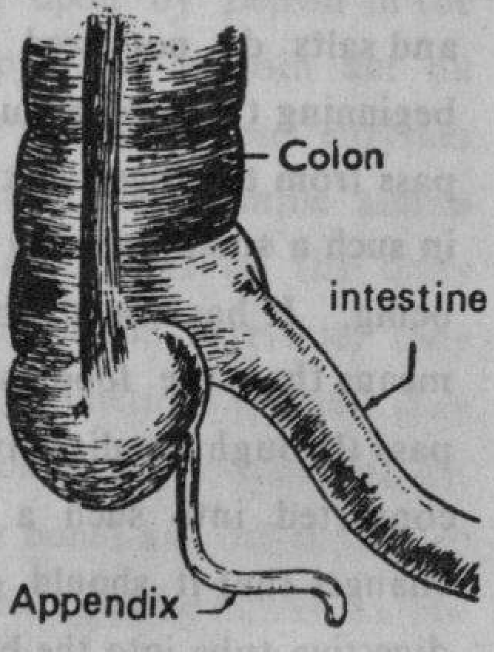
In the posterior part of the buccal cavity is present the throat from where two tubes lead and pass down into the thorax. The dorsal tube is the one through which passes the chewed food and is known as the gullet or *oesophagus*. The ventral tube is the respiratory tube through which air always comes in or goes out of the lungs. The bolus of food, after having been ground, becomes fine and when it becomes soft after mixing with saliva, it is pushed back by the tongue into the gullet. At the time of passing of the bolus into the gullet there is always a danger that it may not pass into the respiratory tube. Nature has prevented this by providing a lid at the opening of the respiratory tube, which usually remains open but when the bolus of food is passing into the gullet, the lid closes the opening of the respiratory tube automatically.

The muscles in the wall of the gullet are so strong that even if a man eats or drinks while hanging with head downward, the food passes from the gullet into the stomach. In fact when anything enters the gullet, the walls of the gullet press it in such a way that it passes into the stomach. Anything that comes under their influence is pushed into the stomach.

At the end of the gullet there is a sac like structure called *stomach* and it can contain two to two and a half seers of water or any other food. The function of the stomach is not as much to digest the food as to make the food soft by churning and make it a semifluid substance which is known as the *chyme.* When the food reaches the stomach, thousands of glands present in its walls start secreting a digestive juice. The juice of the stomach contains one part of weak hydrochloric acid and one part of an enzyme known as the *pepsin* in addition to water. As the saliva starts the digestion of the carbohydrates of the food, the pepsin starts the digestion of proteins. The complete digestion of carbohydrates and proteins takes place later on, but this process just starts in the stomach.

The stomach leads into the *intestine*. Its first part is known as the *duodenum.* The tubes which bring juices from two large glands (the liver and the pancreas) open into the duodenum. The juice from liver which is known as the bile starts the digestion of fats in the food, which is a physical change and not a chemical change. The juice from the pancreas contains a number of enzymes which have a strong chemical action. In addition to this a digestive juice is also secreted from the walls of the intestine which contains many enzymes. The small intestine which is about 6 meters long starts at the end of duodenum. In the first half of small intestine the process of digestion takes place and in its second half the products of this process are absorbed in the blood.

Large intestine or the colon starts at the end of the small intestine. Near this point an additional part of this large intestine which is like a thumb, is hanging out which is known as the *appendix*. The appendix is not only a useless structure but rather a troublesome part, in which sometime pain starts and the doctors remove it by operation from the abdomen. The colon is much wider than the small intestine. After making a complete circle in the abdomen it ultimately opens out at the anus. The



different parts of the food have been digested when the food reaches the colon and only waste products or faeces are left behind. The faeces go on collecting in the colon for hours and then it is passed out once or twice a day.

1.3 Process of Digestion

We take the food into the stomach but it is of no use unless it is digested. By digestion of food we mean that the food in the stomach and other part of the digestive tube should undergo different chemical and physical changes and it should reach such a condition that it may diffuse through the walls of the stomach and intestines into the blood.

The main parts of the food are the *carbohydrates*. *proteins*, *fats*, *vitamins*, *salts* and *water*. Water and salts do not need digestion because from the very beginning they are in such a form that they can directly pass from the digestive tube into the blood. Vitamins are in such a small quantity that we neglect them for the time being. It has already been described that digestion only means that the food which under normal form cannot pass through the digestive tube into the blood, should be converted into such a form by chemical and physical changes that it should diffuse through the walls of the digestive tube into the blood.

In the process of digestion the larger molecules of food are changed into such simpler forms by chemical processes that they are now able to enter the blood by diffusing through the walls of the digestive tube. In this process different enzymes take part which are secreted in the buccal cavity, digestive tube, liver and pancreas. First of all we take the carbohydrates of the food. The enzyme ptyalin which is a part of the saliva, starts acting on these in the buccal cavity. This process is continued and by the action of amylase on the carbohydrates in the stomach and intestine, these are converted into simple glucose. Glucose passes into the blood from the intestine and then goes to the liver and other parts of the body where it is oxidised and produces energy.

Proteins are first of all acted upon by pepsin in the stomach and then the enzymes trypsin and erepsin act on them in the intestine. Due to the action of these enzymes the proteins are ultimately converted into simple amino acids. When these reach the different parts of the body after passing through the walls of the intestine, they perform two functions. One of the functions is that they burn in the oxygen of respiration and produce energy. Secondly they form new flesh, new bones and other tissues. This second function cannot be performed by either carbohydrates or fats, it can only be performed by the proteins.

Large drops of fats are first converted into an emulsion formed of small droplets by the action of bile from the liver and then by the chemical action of the enzyme lipase from the pancreas it is converted into fatty acids and glycerine. When these burn in the oxygen, they produce energy for the body.

We can, however, conclude that the food, which was in the beginning in the form of vegetables, meat, pulses bread and butter, by the action of many physical and chemical changes is digested and passed into the blood. After this either it produces energy by burning in the oxygen or it replaces the worn out tissues of the body.

1.4 Circulatory System

The blood is an indispensable means for the maintenance of life and it is present in our body everywhere but not as there is water in a bottle or food in the stomach. The blood is present in the body inside special vessels and these vessels are present everywhere, These vessels on one hand are connected to the heart and on the other continue dividing into branches till they become so thin that they are not visible to the naked eye. In this condition they are known as the *capillaries* and these are the most important part of the circulatory system.

1:5 Structure of Blood

The blood on the first sight appears as a homogenous red coloured fluid but on careful examination it will be found that the blood is composed of a colourless fluid and yellow coloured particles floating in it. The fluid is known as the *plasma* and it is a non-living substance. The particles are known as the corpuscle and they are living cells. All the corpuscles are not of the same kind. They are of two kinds. Majority of corpuscles are plate-like in shape and yellow in colour and they are known as the *red blood corpuscles.* Some corpuscles are colourless and of an irregular shape and known as the *white blood corpuscles.* According to an estimate there are about five crore red blood corpuscles and one lakh white blood corpuscles in a drop of blood. In every red blood corpuscle there is

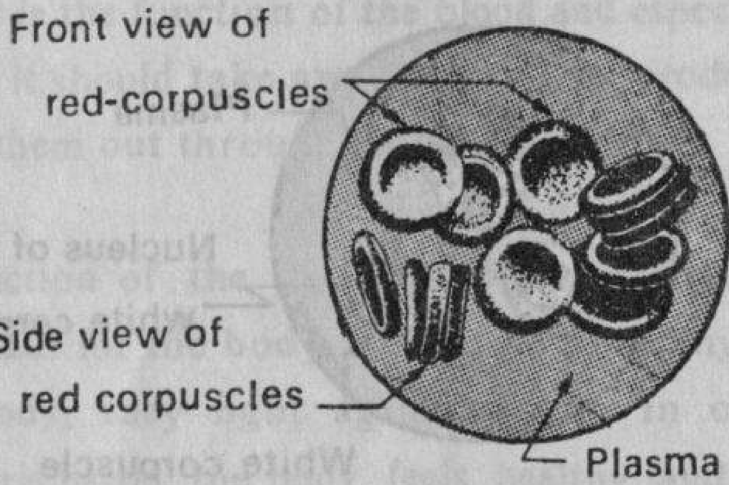
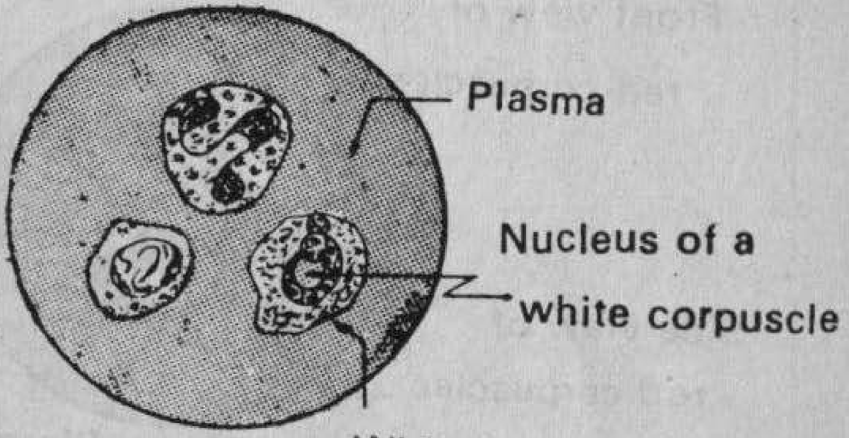


Fig. 1.3

a coloured chemical substance, the *haemoglobin*. The red colour of the blood is due to the presence of haemoglobin.

Every small organ, tissue and cell in a living body needs digested food and oxygen. If it does not get both these things, it cannot live. Both of these necessities can reach every small part and corner of the body only through a fluid medium. Therefore nature has made blood a fluid so that oxygen and food may get dissolved in it and reach every small corner of the body. The red blood corpuscles take up, carry and distribute the oxygen. They take up oxygen from the lungs and then while floating in the plasma, distribute the oxygen wherever they go. In addition to the transport of corpuscles the plasma also carries the digested food to the different organs of the body. These two functions are the most important function of the blood.



1.4

Every organ, tissue or cell which is living, needs oxygen for respiration and food for getting energy. As a result of respiration and digestion a few waste products are also produced which must be removed from the body. Therefore it is the function of the blood and especially the plasma that it should take away these waste products and then throw them out through the kidneys, lungs and the skin.

The function of the white blood corpuscles is also very important for the body. If the germs of any disease enter the body, they fight against them. In case they succeed in this battle, the body feels healthy and if they fail, the disease attacks.

1.6 The Heart, Arteries, Veins and Capillaries

It has already been described that blood is such a fluid which provides oxygen and food to the smallest part of the body and takes away the waste products produced there to the excretory organs. Now we have to see from where and how the blood takes the oxygen and food and the mechanism by which they reach the distant parts in the body.

The function of this transportation is performed by the heart and those vessels which come to the heart or go away from it and which are known as the *veins* and the *arteries*. The blood first goes from the heart to the different parts of the body through the arteries. Then it passes through the capillaries and collects in the veins which take it back to the heart. The blood while flowing through an organ leaves the food which is needed there and takes up the waste which has to be removed.

1.7 The Heart

The heart is of the size of a closed fist which is situated in the chest a little to the left under the IV,V and VI rib. The walls of the heart are made up of very strong muscles but it is hollow from inside and is full of blood. Its function is to contract and expand alternately like a pump. When it contracts, the blood present in it is pressed and it flows in those large vessels which are known as arteries. When the heart expands, the vessels which are known as the veins pour into it the blood which has returned from the body. The heart contracts and expands seventy two times in one minute on the average and we can feel this movement on our wrist in the form of pulse. The arteries, on coming out of the heart, go on dividing and reach every part of the body. The branching of the arteries is just like the stem of a tree which goes on dividing into branches.

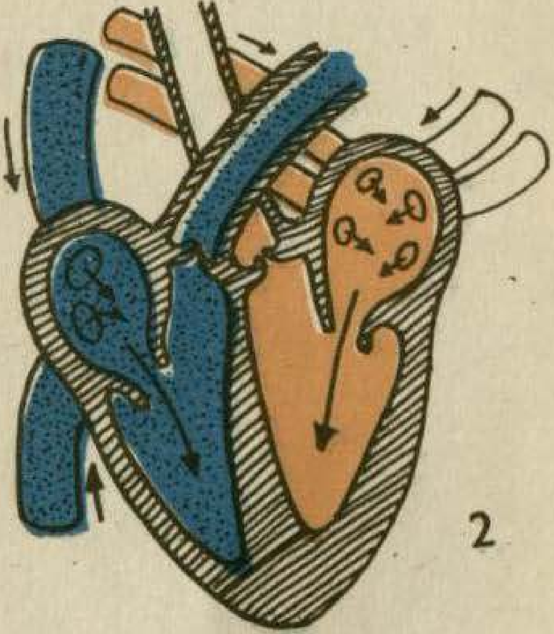
1.8 Circulation of Blood

On looking carefully at the figure in Plate No. 1, we find that the heart is not a single pump but is a combination of two pumps lying side by side and they are united so as to form one structure. The blood that enters the right pump is the one which has just returned after completing a circle in the body. This blood has been supplying oxygen to different organs of the body and is now almost without oxygen. As it has also passed through the

Plate I

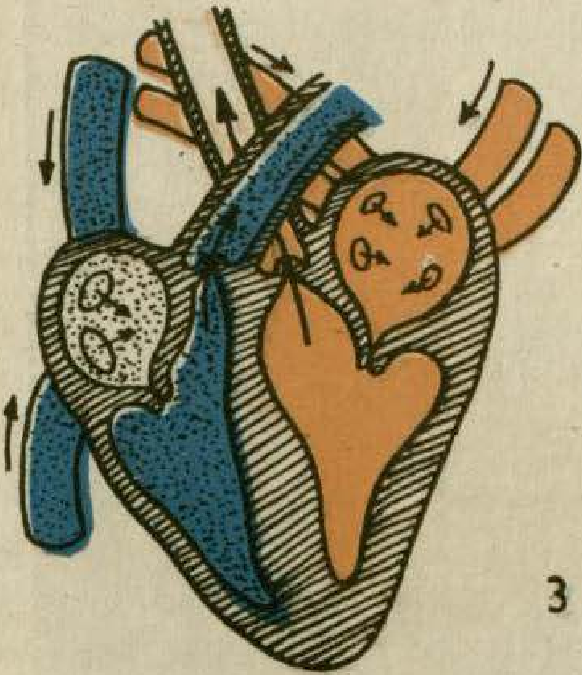
1

External view
of heart



2

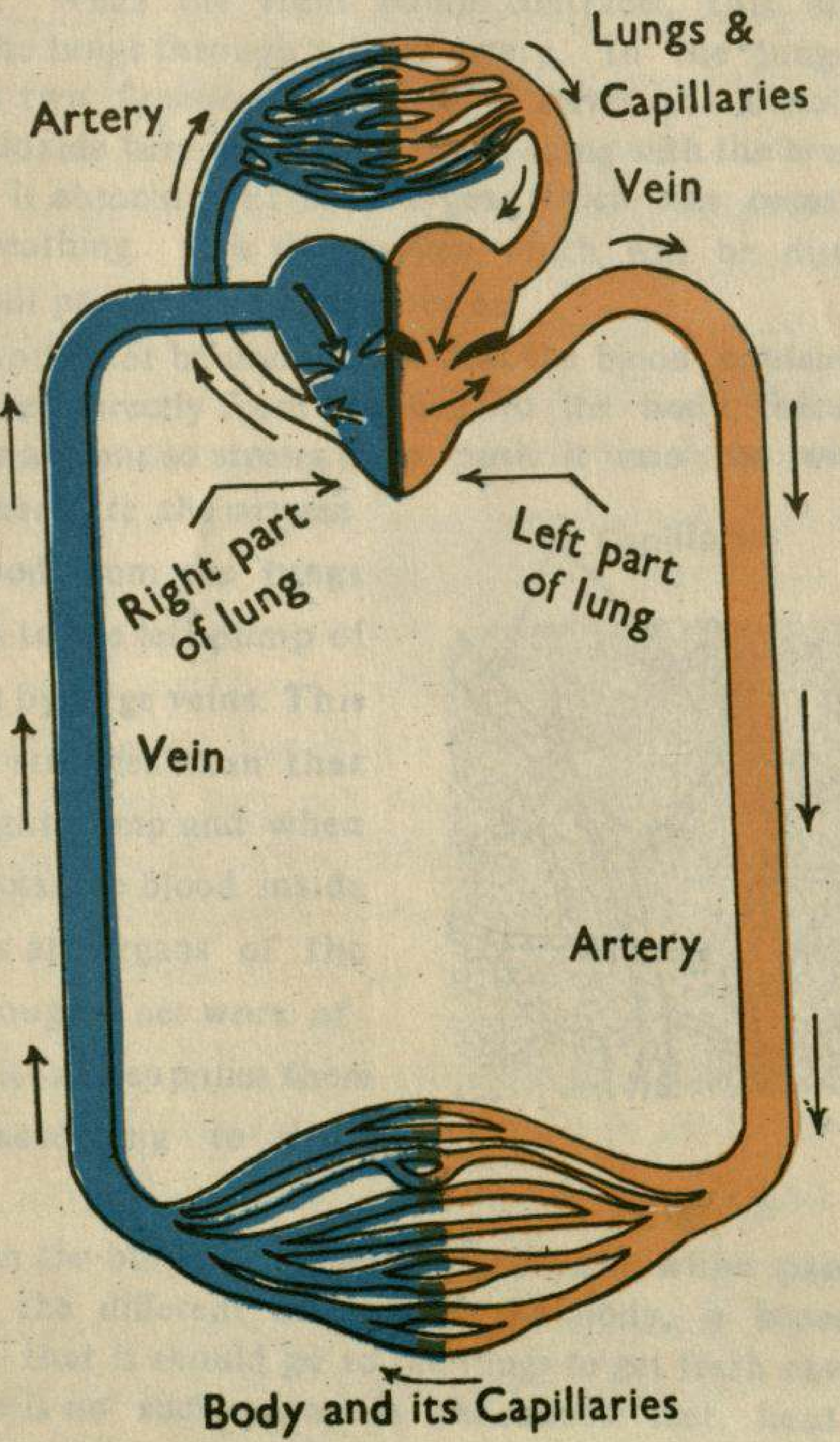
Internal structure
of heart



3

The blood entering
the main arteries

Plate 2


Lungs &
Capillaries
Artery
Vein
Right part
of lung
Left part
of lung
Vein
Artery
Body and its Capillaries

iver and intestine, therefore it has brought with it digested food. When the right pump contracts, this blood goes to the lungs through a large artery. In the lungs it performs two functions. Firstly it leaves the dissolved carbon dioxide here which comes out along with the breath. Secondly it absorbs the fresh oxygen which has come in during breathing. It is this oxygen which will be distributed to all parts of the body later on.

It should not be understood that the blood containing oxygen goes directly from the lungs to the body, because the lungs are not so strong as to push it into the whole body. Therefore the oxygen laden blood from the lungs first goes to the left pump of the heart by large veins. This pump is stronger than that of the right pump and when it contracts, the blood inside it reaches all organs of the body through a net work of the arteries and supplies them oxygen according to their needs.

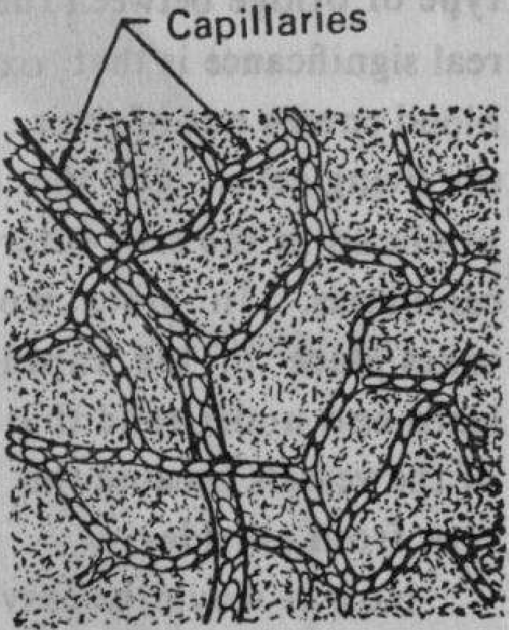


Fig. 1.5

When the blood is depleted of oxygen while passing through the different organs of the body, it becomes necessary that is should go to the lungs to get fresh oxygen but there is no such pump in the hands, feet, head or abdomen which could send this blood to the lungs. Therefore it flows slowly through wide loose veins first into the right half or pump of the heart and when this pump contracts, the blood is forced into the lungs. From the lungs this blood comes back into the left side of the heart. When the heart contracts, the blood flows out to all parts of the body through the arteries.

The arteries after dividing many time become very thin walled. These very thin vessels which are not visible to the naked eye are the capillaries. The capillaries are a type of bridge between the arteries and the veins but their real significance is that oxygen and food dissolved in the blood comes out of their thin walls by diffusion and reach the living cells. On the other hand the waste products produced in the cells enter the blood through the walls of capillaries. In other words the real function of blood takes place in the capillaries only. It is important to learn and understand that the blood at no stage comes out of the vessels because the circulatory system is of closed type from all sides.

Now it would be easy to understand that there are two circuits of the blood. One circuit is that which is between the heart and the lungs and in this circuit the blood which is without oxygen, goes to the lungs under pressure from the right pump and after getting oxygen from there comes into the left pump. The second circuit of the blood is the one which works between the heart and other parts of the body. In this circuit the blood full of oxygen is supplied from the left pump of the heart to the organs of the body where it leaves its oxygen and comes into the right pump of the heart *i.e.*, the complete circle of blood is not a single circle but is like two circles which join one another to form a figure of '8' (Plate No. 2)

1.8 Respiratory System

Respiration is the process of breathing. Therefore the organs which take part in respiration are collectively

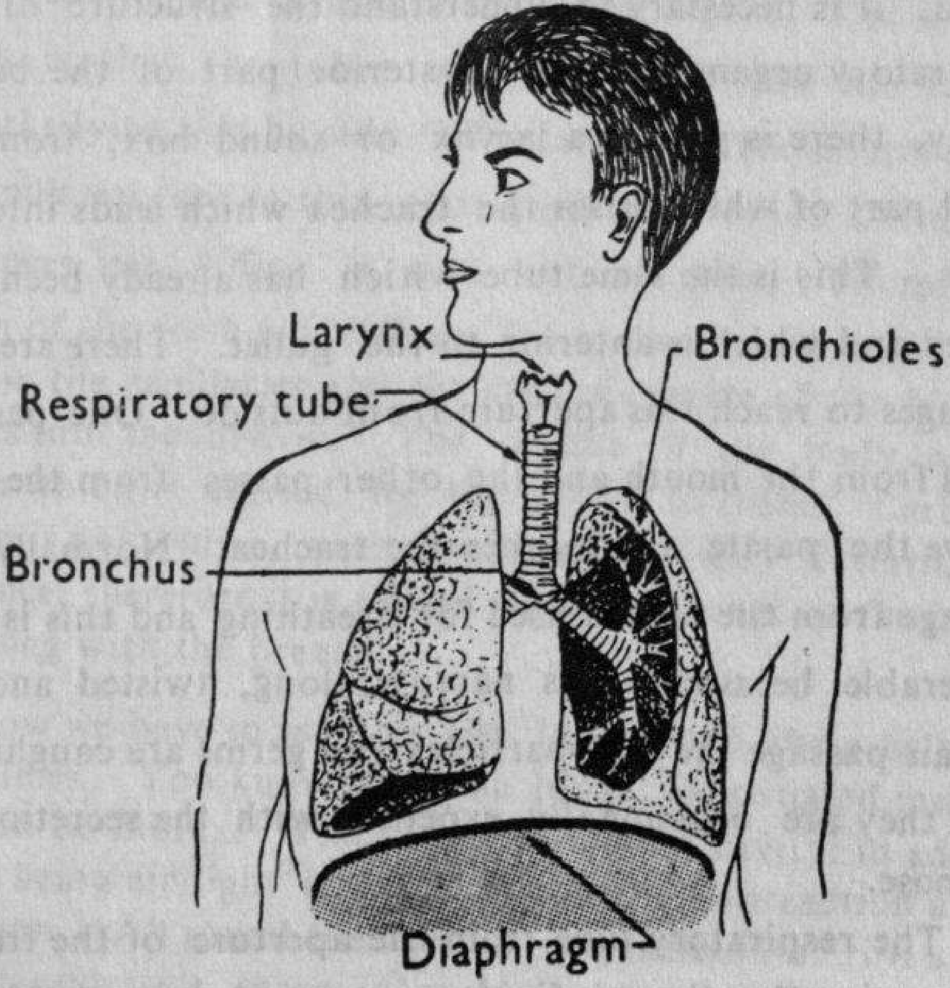

Larynx
Bronchioles
Respiratory tube
Bronchus
Diaphragm

Fig. 1.6 Respiratory System

known as the **raspiratory organs.** These consist of a pair of lungs which are situated in the thorax . During breathing the air comes in and goes out of lungs. In fact lungs are such organs where currents of air and blood while moving in their own paths, join one another and by their union all organs, tissues and cells of the body, get oxygen without which they cannot live.

To know how does the air reaches the lungs and how does the oxygen separates from air and mixes with the blood, it is necessary to understand the structure of the respiratory organs. In the posterior part of the buccal cavity, there is present a larynx or sound box, from the basal part of which arises the trachea which leads into the lungs. This is the same tube which has already been described and which is anterior to the gullet. There are two passages to reach this aperture from outside. One passage leads from the mouth and the other passes from the nose above the palate and reaches the trachea. Normally the passage from the nose is used for breathing and this is even preferable because in this narrow, long, twisted and full of hair passage the dust particles and germs are caught and then they are occasionally expelled with the secretions of the nose.

The respiratory tube from the aperture of the trachea on entering the thorax divides into two tubes, each one entering the lung of its own side. These tubes are known as the *bronchi*. There are rings of cartilage in the walls of the tracheal tube and the bronchi due to which these tubes cannot collapse. Therefore the air enters and leaves the lungs with out any obstruction. The respiratory tubes go on dividing even after entering the lungs till they terminate in a very small and thin walled *alveoli*.

The large arteries which enter the lungs from the heart divide, redivide and spread in the whole organ. The result of this is that the tubes carrying blood and air form networks lying side by side. The walls of the alveoli and the capillaries are so thin that gases and other chemical substances can diffuse in and out of them. Therefore oxygen of the fresh air diffuses from the alveoli into the blood in the capillaries and the carbon dioxide of the blood diffuses into the alveoli. The organs of the body need oxygen which is carried by the blood to them. Carbon dioxide is not only a waste product but also a harmful substance, therefore it is passed from the lungs to the outside along with the breath.

Now we have to see how the lungs work like a bellow at all times. You know that the lungs are situated inside the chest or thorax. The conical thoracic cavity in addition to being air tight is also capable of contraction and expansion. All round the thorax is a skeleton of ribs and on the underside there is a muscular partition or the *diaphragm*. The thorax is capable of contraction and expansion and the diaphragm is capable of up and down movement. When the ribs expand and the diaphram is pushed down, the cavity of the thorax enlarges. The result is that the air from outside passes through the nose and the trachea and reaches the lungs, but due to the natural elasticity the ribs and the diaphragm come back to their original positions. Due to this the cavity of the thorax contracts and along with it the lungs also contract. Thus the air from the lungs comes out. This process of expansion and contraction of the lungs continues at all times.

1.9 The Nervous System

In the beginning of this chapter we described that different organs perform their functions for the good of the whole body. But many questions arise here. How do the different organs decide to start their work? How much work should a particular organ perform? What should be the rate of performing work? When should an organ stop functioning?

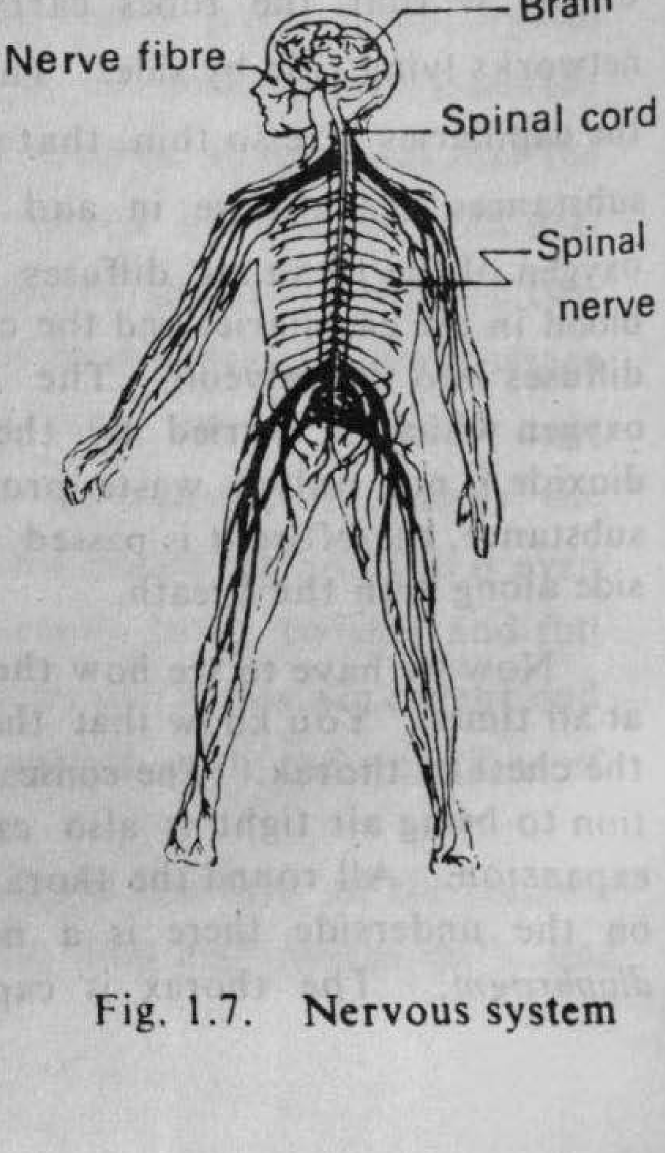


Fig. 1.7. Nervous system

In other words we want to know the factor which develops a co-ordination in the working of different organs. The co-ordination in the different organs of the human body is brought about by the nervous system. The nervous system is in the form of a network from which all the organs of the body receive their nerve supply. The threads of this net-work and other parts are affected by the external and internal environments.

1.10. Parts of the Nervous System

The nervous system is divided into three main parts. First part consists of the sense organs. These organs are mainly present on the external surface of the body and are affected by the external conditions like heat, cold, light, sound and odour. Eyes, nose and ears are its common examples.

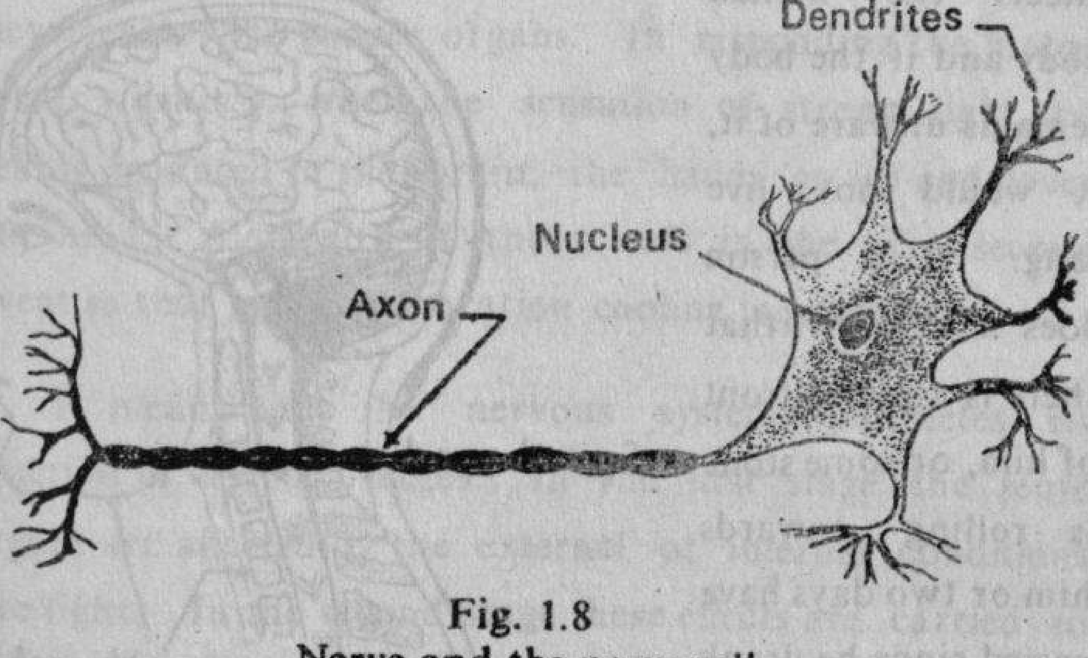


Fig. 1.8
Nerve and the nerve cell.

Second part of the nervous system is the nerves. The nerves are white coloured long threads. The effects of heat, cold, light or sound on the sense organs are carried by these nerves to the brain and the spinal cord like the telephone wires. The brain and the spinal cord acts as central telephone exchange.

Third part of the nervous system consists of brain and spinal cord. The brain is situated in the skull and the spinal cord is present inside the vertebral column. The nerves which reach them or leave them pass through apertures in the skull and the vertebral column.

1.11. Working of the Nervous System

Any change in the external environment affects the human body and if the body remains unware of it, it would not live long. If a person does not know that there is a pit in front of him, or some stone is rolling towards him or two days have passed since he drank

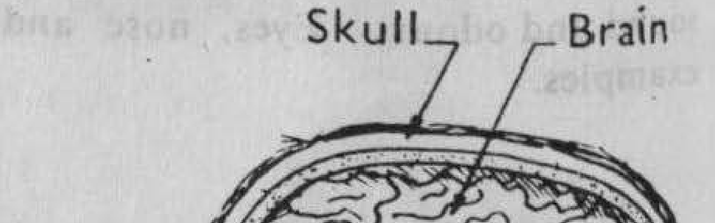


Fig. 1.9. Brain and the Spinal Cord.

water then perhaps he may live for some time with the help of some body else but he cannot survive for long and moreover there is no use of such a wasteful life. Nature has thus provided the body with different kinds of sense organs on its external surface. Some of these, which are present in the skin are stimulated by the heat, cold or pain. They, in turn, stimulate the brain through the sensory nerves where the feeling of heat, cold or pain is produced. Similarly the light produces a stimulation in the eye which reaches the brain through the optic nerve where the feeling of sight is produced.

When the sensation of heat, cold, pain or light is produced in the brain, then the body responds to it by the mevement of the proper organs. In responding the motor nerves work *e.g.*, when the sensation of strong light and heat is produced in the brain, the hands go up and cover the head. Alongwith it the glands in the skin secrete sweat so that by its evaporation cooling is produced.

It means that the nervous system completes its function in various stages. In the first stage the sense organs are affected by the external or internal conditions like light. In the second stage these effects are carried to the central part of the nervous system *i.e*, the brain or the spinal cord through the sensory nerves. In the third stage they affect the brain which ultimately understands it *i.e.*, the knowledge or understanding of something takes place in the brain. The eye, ear, skin and their nerves are no doubt affected by the light, sound or heat but none of these reaches the state of understanding the effect. The understanding or working takes place in the brain only. After knowing about the happening inside or outside the body, the brain suggests a proper action and sends an order to bring into action the proper organ. In the fourth stage the order reaches the organ which is to be brought into action through the motor nerves and ultimately that organ is brought into action.

EXERCISE

1. Make a sketch to show the different types of foods and the enzymes which digest them.
2. Draw a diagram to show how the vessels take the blood from the heart to the lungs and back?
3. Name the different corpuscles of the blood and their functions.
4. What function does oxygen perform for the body after it has been absorbed in the blood?

5. From which special part of the circulatory system the dissolved oxygen, carbon dioxide, salts and digested food can diffuse out or diffuse in and why?
6. How does the air enter and leaves the lungs?
7. What are the three main parts of the nervous system?
8. Why brain and the spinal cord are considered as a telephone exchange?

2

Health and Sanitation

Health is wealth and every intelligent person tries to maintain his health. In all ages educated persons and physicians have been trying to understand as to why a healthy person falls sick and how does he recover after sickness. Many principles were framed to maintain health *e.g.*, eating good and balanced diet, spending time in the open air and sunlight, taking exercise regularly, taking proper rest, and avoiding smoking and narcotics. Man can protect himself from diseases and keep himself healthy observing these principles, but inspite of these man falls sick. Scientists are trying to know the causes of diseases since early times but have not succeeded much and till now we are not fully aware of the causes of the diseases and their cures. However, time has also passed when diseases were thought to be the effects of evils or a result of some change in four dimensional admixtures, *i.e.* water, Air, Earth and Fire.

2.1 Germ Theory of Diseases

The diseases which attack man are not due to any one cause, rather each disease has its own cause. Some diseases are communicable *e.g.*, small pox, tuberculosis and cholera. About two hundred years back no body knew how these infectious diseases are communicated from onc person to the other. Physicians and doctors while investigating certain diseases found certain living organisms in the body or sputum of the patients and so it was presumed that these living organisms did not arise by themselves but have entered the body from outside through some means. These small organisms are called the *germs*. In the beginning these germs were not considered to be disease causing, but when the same type of germs were found in the same type of patients, it was believed that these germs are the cause of the disease. These germs enter the body of man to get their food and they start eating the tissues of the body due to which man falls sick. The disease appears in the form of pain or fever. Now there is no doubt that the diseases are due to germs and each disease is caused by a different kind of germ, In this chapter we shall describe some diseases which are caused by germs so that we could know the dangerous results produced by germs.

2.2 Malaria

It is a fever which becomes more common after the rainy season. Before the fever the patient shivers with cold and his teeth chatter. Alongwith this the tempertture of the patient begins to rise which sometimes reaches 106°F. After a few hours the patient sweats and the temperature starts decreasing. Next day the temperature does not rise at all but the next day the same symptoms appear *i.e.*, feeling of cold, shivering of the body and the rising of temperature. Like this there are a large number of attacks of the fever.

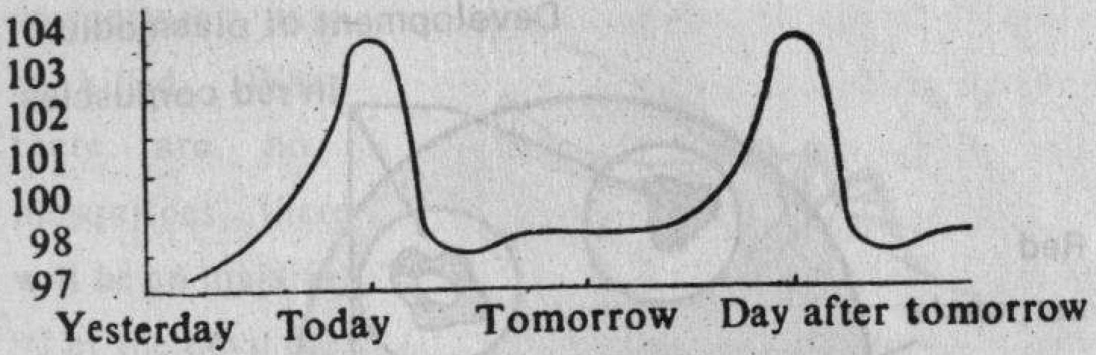


Fig. 2.1

In malaria temperature rises on one day, comes down the next day and rises again on the third day.

The red blood corpuscles in the blood decrease in number. The patient becomes pale and feels very weak.

The fever can be treated by taking fifteen to twenty grains of Quinine daily (during the fever days).

Malaria is caused in man due to the entry of a kind of germ known as the *plasmodium.* These germs are present in the stomach and buccal cavity of anopheles mosquito. When the female mosquito bites a person, these germs enter the blood of man. In the blood these germs enter the red blood corpuscles and start eating them. They grow inside the red blood corpuscles and reproduce here. During reproduction the poisonous substance that is produced comes into the blood on the bursting of the red blood corpuscles and the temperature rises.

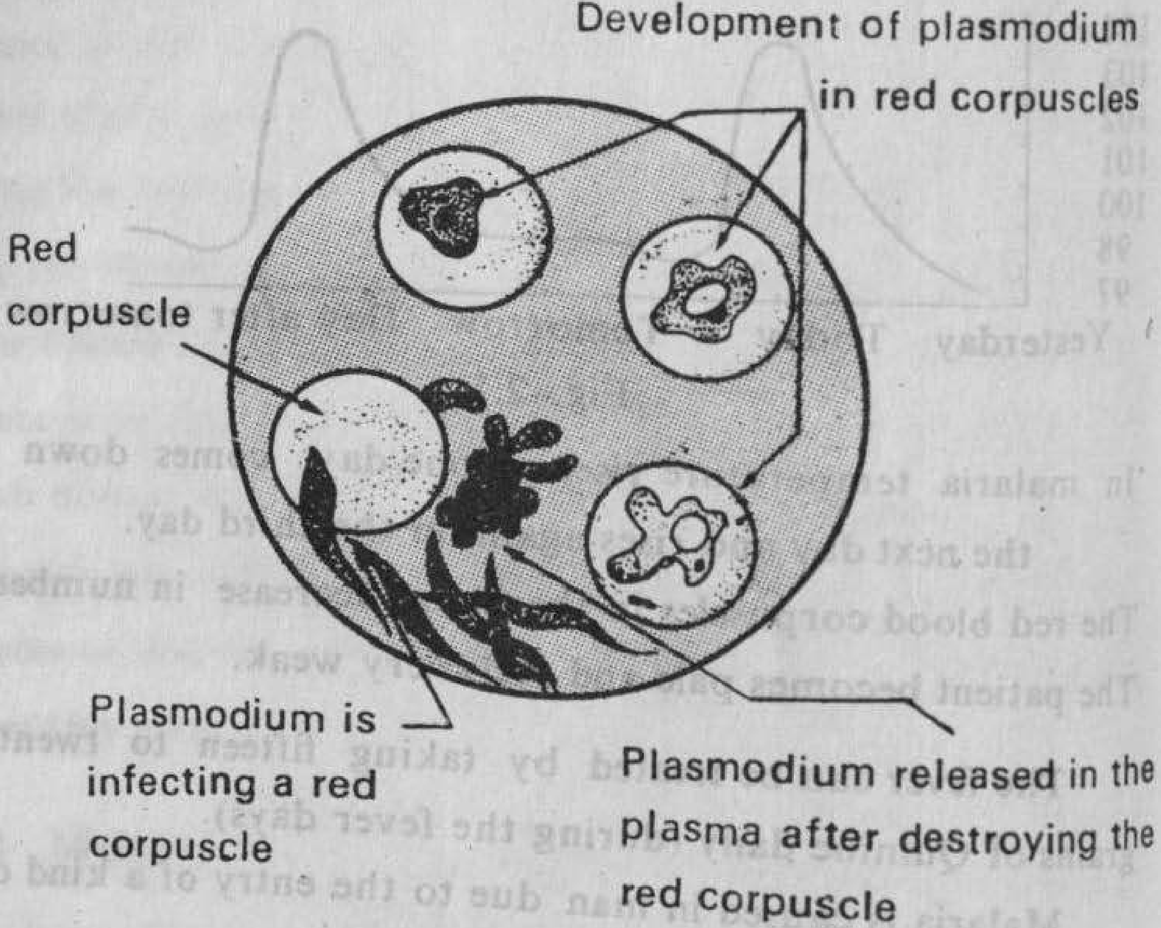
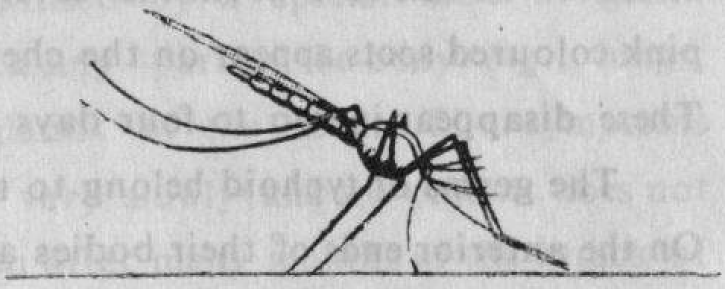

Development of plasmodium in red corpuscles
Red corpuscle
Plasmodium is infecting a red corpuscle
Plasmodium released in the plasma after destroying the red corpuscle

Fig. 2.2.

Now you have come to know that malaria is caused by the biting of the mosquito and the mosquitoes are produced after the rainy season in dirty water of ponds and pools. It is, therefore, necessary that the ponds and pools present near your houses or dwelling places should be filled with earth or kerosine oil be sprinkled on them or D.D.T should be sprayed in houses, on ponds and pools so that all the



mosquitoes may be killed. When there are no mosquitoes, there will be no malaria. "Let the devil die, let the evil finish."

Fig. 2.3
Mosquitoes which spreads malaria.

2.3. Typhoid

It is also known as a time long fever, because the fever goes down after completing its limit of fourteen days or twenty one days. In the beginning the patient feels depressed with headache and pain in the limbs. The patient does not feel like eating. In the evening the temperature rises and in the morning it decreases but not below the normal temperature. At the end of the first week the temperature rises upto 103°F. In the second week the temperature remains constant. In the third week in the morning the temperature is 99°F and in the evening it is 101°F or 102°F. In the fourth week the temperature become normal first in the morning and then in the evening and thus the patient recovers.

Typhoid fever is also known as the enteric fever because the germs which cause this fever start living in the intestines where a large number of sores and wounds are formad. In this fever from the seventh to the twelfth day pink coloured spots appear on the chest, belly and waist. These disappear in two to four days and then reappear.

The germs of typhoid belong to the family of bacteria. On the anterior ends of their bodies a few hair are present. A large number of these are passed out with the faeces. When flies sit on the faeces, the germs stick to the bodies of the flies: When these flies sit on naked food or water, the germs enter the food or water. When a healthy person eats this food, these germs enter his stomach and cause typhoid fever.

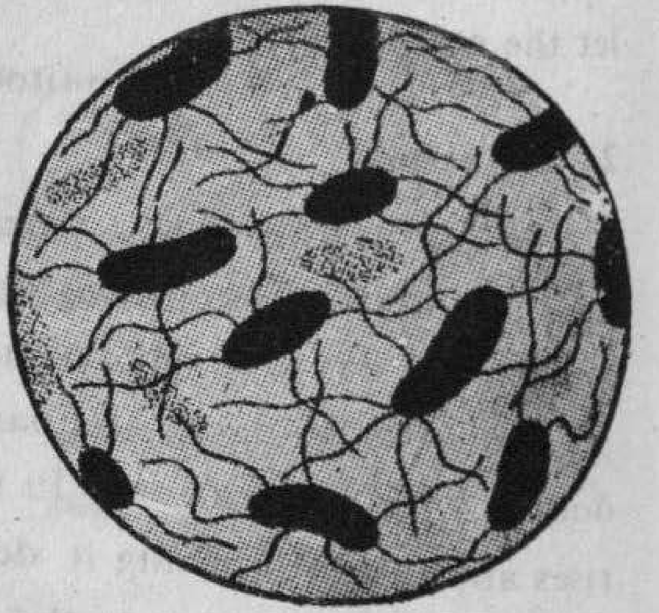


Fig. 2.4

Bacteria causing Typhoid Fever.

During the days when this fever has spread in the form of an epidemic, water should be taken after boiling. The food under ordinary conditions should be protected from flies but during these days the food should be specially protected from flies and cleanliness should be maintained.

2.4. Tuberculosis

It is a fatal disease which kills the patient slowly and gradually. This is caused by a special kind of germ. These germs can attack any part of the body *e.g.*, lungs, intestine, bones and glands of the neck. The symptoms of this disease appear very slowly and the patient does not feel that he is sick even after many months of the attack of this disease. The patient suffering from tuberculosis of the lungs first of all gets dry cough and then spits yellow coloured sputum. Sometimes alongwith the sputum a little blood is also passed out. The patient sweats profusely at night. The patient feels tired at all times and runs slight temperature. He loses apetite and weight is lost day by day and ultimately the patient dies.

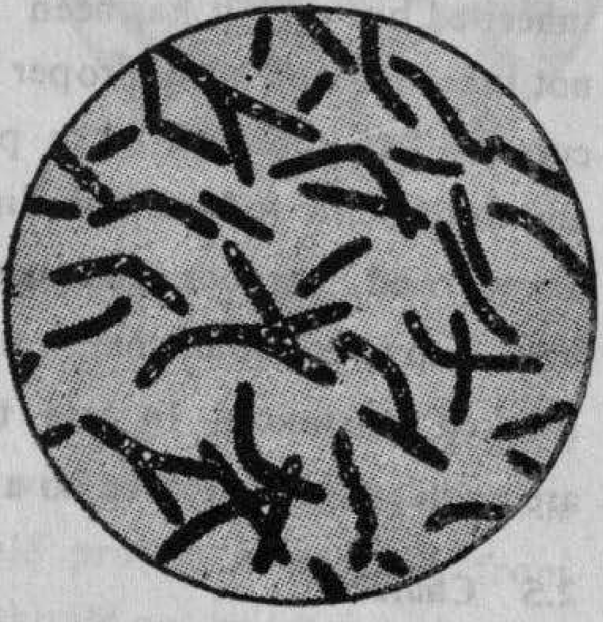


Fig. 2.5
Bacteria which cause tuberculosis.

The tuberculosis of the intestine is very slow and the patient suffering from it, live for many years. The tuberculosis of the bones cause ulcers and tuberciosis of the neck glands cause glandular tuberculosis.

The germs come out when a patient of tuberculosis coughs or spits and float in the air. By breathing in such an air the germs enter other persons. Some healthy persons can resist these germs but such persons who are weak due to some reason or whose power of resistanc is low fall sick on the first attack of the disease.

In the beginning it was thought that this disease is inherited but now it has been proved that this disease is not inherited and with proper treatment the patient can be cured. This disease attacks persons who take insufficient and unhygienic food, live in dirty and water-logged houses, are worried, nervous and use narcotics or persons who have recovered from some disease and have very much reduced resistance. In case the above mentioned causes are avoided, there can be no attack of tuberculosis.

2.5 Cholera

This is a dangerous disease which is caused by germs. These germs enter the eatables, reach the digestive system and cause cholera. These germs also belong to the family of bacteria. The body of these germs is curved and at each end there is a hairy part.

Usually this disease attacks at night or early in the morning when resistance is low. The patient starts vomiting and suffers from diarrhoea. The urination stops and there is a tension in the addomen and the legs. The skin becomes very cold, the pulse rate slows down and sometimes the patient becomes unconscious.

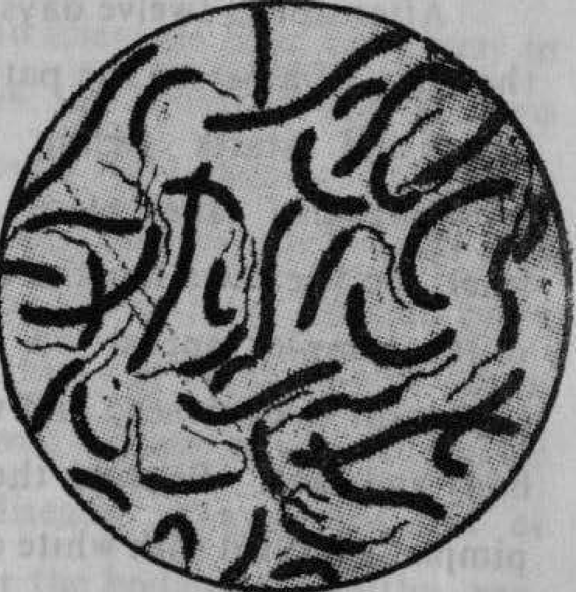


Fig. 2.6
Bacteria which cause Cholera

These germs are passed out with the vomiting and by floating about in the air enter the eatables or water and like this reach other persons. They may also reach the eatables through the flies. If the disease is not treated immediately the patient dies within one day. During the days of this epidemic we should protect the eatables from flies. Raw and rotten fruits should not be eaten and water should be boiled before drinking.

2.6. Small Pox

This is a very dangerous and fatal disease and is communicated from a patient to healthy persons in no time. This disease is also due to germs which are not bacteria but are known as virus. Virus are much smaller than bacteria and hundreds of viruses can be accommodated in the body of one bacterium.

After about twelve days of the entry of the germs in the body of a person the patient feels pain in his back and head and starts feeling cold. In addition to this vomiting also takes place and the patient suffers from fever. On the third day the temperature falls and red coloured pimples appear on the body. The pimples first appear on the forehead and wrist and then on the whole body and face. Between the third and the sixth day these pimples get filled with white coloured fluid. On the eight day the pimples become larger in size and the white fluid is changed into pus. On the twelfth day these pimples either burst or become dry and are covered by black coloured scales. After this even scales falls off and the body is left with deep scars of small pox,

The germs of small pox are present in the breath of the patient and the disease is communicated to a healthy person on sitting near him, touching him or on using his clothes and other articles.

The patient of small pox should be isolated from other persons and especially from children. The clothings, bed covers and other articles in use of the patient should be cleaned with some germicidal medicine.

2.7 Spreading of Communicable Diseases

All diseases do not have one cause. From the very beginning intelligent people and scientists have been busy in doing research in order to know the causes of the diseases but so far they have not become fully aware of the causes and cure of all the diseases. It has, however, become known that some diseases are caused by the entry of special types of poisonous substances in the body of man. These poisonous substances are called *germs.* These reproduce inside the body of man and cause a disease. They come out of the body of a patient and enter the bodies of healthy persons and cause in them the same disease. All those diseases which are caused by the entry of living germs in the body and can be transmitted from one man to another are known as *infectious* or *communicable* diseases *e.g*, cholera, small pox, tuberculosis. The germs of these diseases are present in water and air in the dirty places and reach the human beings through them.

Some infectious diseases are caused by mutual contact of a patient with a healthy person *e.g.*, diseases of the skin and trachoma. There are some diseases which are caused by the biting of insects or by the entry of germs through a wound in the skin.

These germs are almost present at all times in air, water, and in the eatables but inspite of the fact that they enter our body, they do not cause diseases. In fact in the body of a healthy person there is a natural resistance against disease. When the germs of a disease enter our body, the white blood corpuscles present in the blood fight them and kill them. Sometimes the number of these germs is so large that the white blood corpuscles cannot fight them and the resistance of the body collapses. In such a case the disease is caused.

One type of germ is different from the other and can be recognised from its structure. One kind of germ can produce only one kind of disease *e.g.*, the germs of cholera can only cause cholera and germs of malaria can only cause malaria. The germs of a disease can not cause a disease unless they grow and re-produce inside the body of a human being. The germs of infectious diseases can cause a disease only in those persons who have no resistance. The germs grow very rapidly in those persons who live in unhygienic places. These germs not only cause the disease but come out of the patient by different methods and with the help of the air, food, water, flies, mosquitoes, and fleas enter the body of healthy persons and cause the disease.

Infectious diseases start usually from a patient who is either suffering from a disease or is recovering. Sometimes such persons who sit near the patient for a long period or have higher resistance to fight the germs, discharge the germs from their bodies which reach other persons.

The germs of diseases come out with the sputum, vomit, faeces *etc*, and reach weak persons through air and cause diseases *e.g.*, small pox and tuberculosis. The germs which come out with the faeces or vomit enter the water or food or stick to the bodies of flies which sit on them. The germs enter the food when these flies sit on the food and cause diseases on entering the body of healthy persons.

2.8 Control of Infectious Diseases

When the infectious diseases spread, they take the form of an epidemic. It is, therefore, necessary that they should be controlled so that the lives may be saved.

To stop the infectious diseases it is necessary that whenever an infectious disease starts, the department of Health and Sanitation may be informed.

A patient suffering from an infectious disease must immediately be isolated from healthy persons rather it is better to get him admitted in a hospital. The room which is used by the patient must have proper light and air arrangements. The bed of the patient and his utensils should be kept separate and they should be cleaned with germicidal medicines.

Weak persons or such persons who are not capable of fighting the germs of a disease should live in open air, take fresh and good food so that resistance may be developed in them. In addition to this in order to protect ourselves from fatal infectious diseases preventive injections should be taken.

You know that in case a person gets small pox once, he will not get it a second time *i.e.*, by suffering from small-pox once, a patient develops power of resistance against that disease. Taking advantage of this fact, injections have been produced which by entering the blood, develop resistance against the particular disease and the person is protected from the disease. These are known as the *immunity injections*.

The blood has also the property of producing such chemical compounds which neutralise the poisonous substances produced by the germs in the body. These compounds are known as the anti-toxins. These anti-toxins remain in the blood for many years and the person does not get that disease a second time. If the blood of a person which contains these anti-toxins is transferred into the body of another person, the second person will also develop resistance. These anti-toxins can also be produced in the blood of other animals *e.g.* monkeys, horses, and rabbits. These anti-toxin compounds can be used to develop resistance in men.

2.9 Principles of Sanitation

It is necessary for maintaining health that one should act on the principles of sanitation. The most important of these is to keep our environments clean and tidy. The cleanliness includes the removal of smoke that comes out from the chimneys of factories, motor cars, cleanliness of houses, clothings, food, and the surroundings.

As you know there are a large number of germs in the dust, therefore it is necessary to protect ourselves from it. In our country there is scanty rainfall and it is always dusty due to which the germs enter our houses. We should use germicidal medicines for killing these germs. Kitchens, bath-rooms and latrines should be cleaned daily and after washing them with phehyl, germicidal medicines should be sprinkled. The food should be protected from the flies in the kitchen because the flies are always carrying a large number of germs with them and spread many diseases. The drains inside and out side the houses should be washed with phenyl. Piles of filth should be taken outside the city and burnt. Ponds and pools which are close to the dwelling places should be filled with earth or kerosine oil should be sprinkled over them so that the mosquitoes may not breed there.

It is the moral duty of every body to protect himself from diseases and maintain health. Most of the people in our country are illiterate and therefore it is necessary that our public should be fully aware of the principles of sanitation and abide by them.

2.10. Good Public Health Habits

You have come to know that most of the diseases do not spread by themselves which are found in abundance in our surroundings. If our surroundings are not clean, the germs multiply and spread the disease in the form of an epidemic due to which millions of precious lives are lost. Therefore it is necessary that we should keep our surroundings clean and observe the principles of sanitation.

It has been commonly observed that people spit, blow their noses and small children ease themselves here and there. People do not keep the filth in closed boxes but throw them on roads and streets due to which the germs are helped in their growth and distribution.

Excess of carbon dioxide in the air is harmful for the health. Carbon dioxide enters the air from the smoke coming out of homes and factories. It is advisable that a large number of trees and plants should be planted so that the amount of carbon dioxide in the air is decreased. To keep the cities, suburbs, villages clean and tidy, it is necessary that we should keep our streets and houses clean and burn the piles of filth away from the houses. The same advice should be given to our neighbours. There should be a proper ventilation in our houses The ventilators should remain open so that we could get fresh air all the time.

The water whether it is of a river or canal always contains wastes and germs because cattle take bath in the rivers and pass out urine and faeces. Wastes and germs also enter the water of wells, therefore, potassium permanganate should be added to the wells every month. The water from the river or canal should not be used for drinking and if one is obliged to drink it, it must be boiled before drinking. In the cities chlorine or potassium permanganate should be added in the storage tanks of tube wells every month so that all germs may get killed and epidemics may not spread.

We should be very careful about the food. Fresh and light food should be eaten. The food should be protected from the flies. One should not eat to full and the food should be thoroughly chewed.

While building a house it should be kept in mind that the house is not in a low lying area so that the rain water may not collect around the house. The house should not be built at a place where there are piles of filth. There should be proper arrangements for drainage of water and for light and air.

EXERCISE

1. Name the diseases which are caused by germs.
2. Name the germ of malaria. In which system of the human being it is found.
3. What are the things in the blood which protect the human beings against the germs.
4. Give one example each of the diseases caused by bacteria and virus.
5. Describe the symptoms of the following diseases:— (a) Typhoid. (b) Cholera. (c) Small Pox. (d) Tuberculosis.
6. How are the infectious diseases spread?
7. How can the infectious diseases be controlled?
8. Describe the principles of sanitation.
9. Describe the rules which should be observed to maintain public health?

* * *

3

Plants

3.1. Photosynthesis

You know that the food of animals consists of proteins, fats and carbohydrates. One thing that is common in all these parts of the food is that their molecules are large. The animals take them into their stomach and intestine and convert them first into simpler molecules and then get energy to do work by burning them in the oxygen of respiration or they build their bodies by their rearrangement.

But you must have observed that plants neither eat food like bread, nor they have mouth, stomach or intestine. The question then arises how do they grow and from where do they get energy to do work. The answer to this is that plants prepares their own food from the water of the soil salts of the soil and air from the atmosphere. In fact plants have no parallel in the manufacture of food. If you give stores of air, water and salts to the best cook in the world and ask him to prepare any food from it, you will find that he will not be able to do so but the plants manufacture pulses, rice, wheat, mangoes, grapes, apples, oranges and thousands of other eatables from these substance.

The roots of the plants absorb water and simple mineral salts from the soil and send them to the leaves through the stem and the branches. There are a large number of small pores on the leaves and air enters through the pores. Now the air, water and salts meet in the leaves and the manufacture of food starts. In the manufacture of food two other things are also required. One of these is the green substance of the leaves which is known as the *chlorophyll* and the second thing is the sunlight. The food can be manufactured from the air, water and salts only when chlorophyll is present around them and sunlight is falling on them. That is why this process of food manufacture is known as the *photosynthesis*, This process can take place only during the day time in the presence of sunlight. The plants during this process absorb the carbon dioxide of the air and give out oxygen

3.2 Respiration in Plants

The plants also respire like the animals *i.e.*, they take oxygen into their bodies and give out carbon dioxide but the process of breathing or respiration in plants is not clear as it is clear in animals, rather the respiration is overshadowed by the parts produced as a result of photosynthesis. It is, therefore, necessary to study these two functions and understand them separately. Respiration, whether it is in animals or plants means taking oxygen into the body. This oxygen helps the digested food present in the tissues to burn so that energy is produced in the body. As you know that in burning, carbon dioxides is always produced. In animals the production of carbon dioxide is very clear but in plants this is not so clear.

If we examine the atmosphere around a plant during the day time, we shall be surprised to know that the plant is giving out oxygen but at night the same plant will be seen to give out carbon dioxide. Yoy may presume from this observation that the plants respire only at night and during the day time they stop respiring. In fact the respiration never stops and even during the day time the respiration in plants produces carbon dioxide but in photosynthesis the demand of carbon dioxide is very large so it is used up as soon as it is formed and it does not get a chance to get out. On the other hand the production of oxygen during photosynthesis is so much in excess that it is left over even after respiration and starts coming out of the body. The greatest advantage of production of oxygen from the plant is that it replaces the oxygen that is used by the animals. If there were no plants, our atmosphere would have become so much polluted that it would not have been worth breathing.

3.3. Transpiration in Plants

Transpiration in plants means the evaporation of water from the surface of the leaves which reaches there through the roots and stem. The continuous transpiration of water from the surface of the leaves is of great significance for the plant. You know that when the water and salts from the soil reach the leaves of the plant, then in the presence of chlorophyll and sunlight the food of the plant is manufactured.

In plants the reason for the ascending of water to the leaves is not one but are many. Out of these one of the main causes is the continuous evaporation of water from the surface of the leaves. On the under surface of the leaves there are thousands of small pores through which the water evaporates. As the water from the surface of the leaves evaporates, the water is pulled upwards through the roots, stem, branches and stalks of the leaves. Thus a current of water is continuously maintained from the roots to the leaves which brings alongwith it different kinds of salts. If this cnrrent is not maintained, the plants would not be able to manufacture its food. In addition to this the keeping of the plants and the leaves cool in summer is also due to transpiration. As in our case the evaporation of sweat keep our body cool, similarly cooling is caused by evaporation of water in the plant body.

The transpiration current of water is sometimes very fast and sometimes it is very slow. It is apparent that when the season is hot and dry, water will evaporate from the surface of the leaves rapidly and the transpiration current will move fast but when the season is hot and humid or cold the rate of transpiration will be slowed down.

3.4. Hybridisation and Selection

Since the origin of the world the process of reproduction is going on. All animals and plants continue their generation further *i.e.*, every animal produces another animal of its own kind and each plant produces a plant of its own kind *e.g.*, a cow gives birth to such a calf which will grow into a cow or a bull and a Dalbergia tree produces such seeds which will give rise to Dalbergia plant. It is never possible that a cow gives birth to an ass or a Dalbergia tree may bear mangoes. Sometimes it so happens that two different kinds of crops or fruits or animals may cross with one another and a new type of organism may be produced. One of the familar examples is the mule which is produced as a result of cross between a horse and an ass and which is more suitable for transportation of load than both of these.

The coming into existence of a new kind by the crossing of two different kinds is known as the *hybridisation*. According to an estimate, about ten thousauds years ago when man started making pets of animals and cultivation, the hybridisation of fruits, plants and animals also started in an unorganised manner in his society. But now-a-days hybridisation has become a very organised art. Often it so happens that in a particular kind of fruit, crop or animal there are many qualities but alongwith it there is some shortage or weakness which proves harmful. To remove this weakness, experts in the trade search for some kind of organism around him, which may or may not have other qualities but must not have the weakness which is desired to be removed. If the desired kind is available, then it is crossed with the first kind and from the generation which arises as a result of this, such individuals are selected which have good qualities of both the parent kinds.

This may perhaps become more clear from one example. We need such a wheat for making bread, whose flour should have a better fermentation, more Glutin. (Gum like substance) and which should give more yield. In the beginning of this century it was observed that the kinds of wheat which had better flour and more glutin, suffer from disease of the rust more than the other types and therefore they have less yield. Experts in hybridisation controlled this situation. They found a kind of wheat which had lesser amount of glutin but it was naturally protected from the rust disease. This kind of wheat was crossed with a good quality wheat. The seeds which were obtained from this cross when sown, germinated into plants which were all of the same kinds of hybrids. This was the first generation after crossing. When seeds of the first generation were sown in the soil, the plants that grew from these were of different kinds. Some of the plants of the second generation were such that their flour was of a good quality and which were not attacked by the rust disease. These plants were selected and third, fourth and next generations were grown from them and from every generation, plants bearing both the qualities were selected and their seeds were used for further generations.

In a few generations such a wheat was produced, which gave more yield, and was without disease. In this example we have seen that when two kinds bearing different qualities were crossed, the kind with the required qualities appeared in the first and the second generation. Then by selection in the next few generations this combinations was made permanent. By the same method, american cotton with long fibres and sugar cane with more juice has been obtained and now our farmers have started cultivating them.

3.5 Tropic Movements in Plant Organs

The plants are also capable of moving like the animals but their movements are so slow that it can not be said whether they are performing any movement. However, a few examples can be given in which the movements of the plants can be clearly seen. If a branch of forget-me-not plant is touched with hand, its leaves appear to be dropping immediately but generally this is true that the movement in organs of the plants is very slow. If, however, it is desired, then with the help of a film this motion can be shown at an increased rate. If the root that grows on the germination of a seed is photographed after every fifteen minutes regularly for three or four days and then we project it by a cinema projector at a normal speed of sixteen photos per second, the movement of the root will be seen at a rate of three thousand five hundred times faster than the normal movement. It will appear as if the root was an earthworm which was moving down between the sand and hard stone particles.

The movement of the organs of the plant is for the sake of getting light, moisture or for fixing firmly in the soil and this is known as the tropic movement. We shall give here a few kinds of tropic movements. For example the root of a plant always moves away from light, towards darkness and towards the centre of the earth. You may place a seed in any position, may it be inverted, straight or on its side, a root which arises, will always move downwards opposite to light and towards moisture. On the contrary the shoot with leaves that arises from the seed always moves towards light and against the force of gravity. Similarly under normal conditions the leaves keep their surface towards sunlight most of the time, but in summer noon when the sunlight is very strong, they keep themselves at such an angle that minimum light falls on them. These movements are known as the tropic movements. So in other words the root is positively geotropic. positively hydrotropic and negatively phototropic. For a new shoot it will be said that it is negatively geotropic and positively phototropic.

3.6. Internal Structure of the stem and Secondary Growth

The main function of the stem of a plant is to keep its branches and leaves up in the air. Therefore it is necessary that it should be high and strong. So we find that as the weight of the branches and the leaves increases on the stem, the number of the layers of the hard wood go on increasing in it. The second function of the stem is to send the water and salts absorbed by the roots to the leaves. Its third function is to send the manufactured food from the leaves to the parts where it is needed or where it is to be stored.

Inside the stem there are two-way passages. Through one of the passages water and salts reach the leaves and through the other passage prepared food reaches the different parts of the plant.

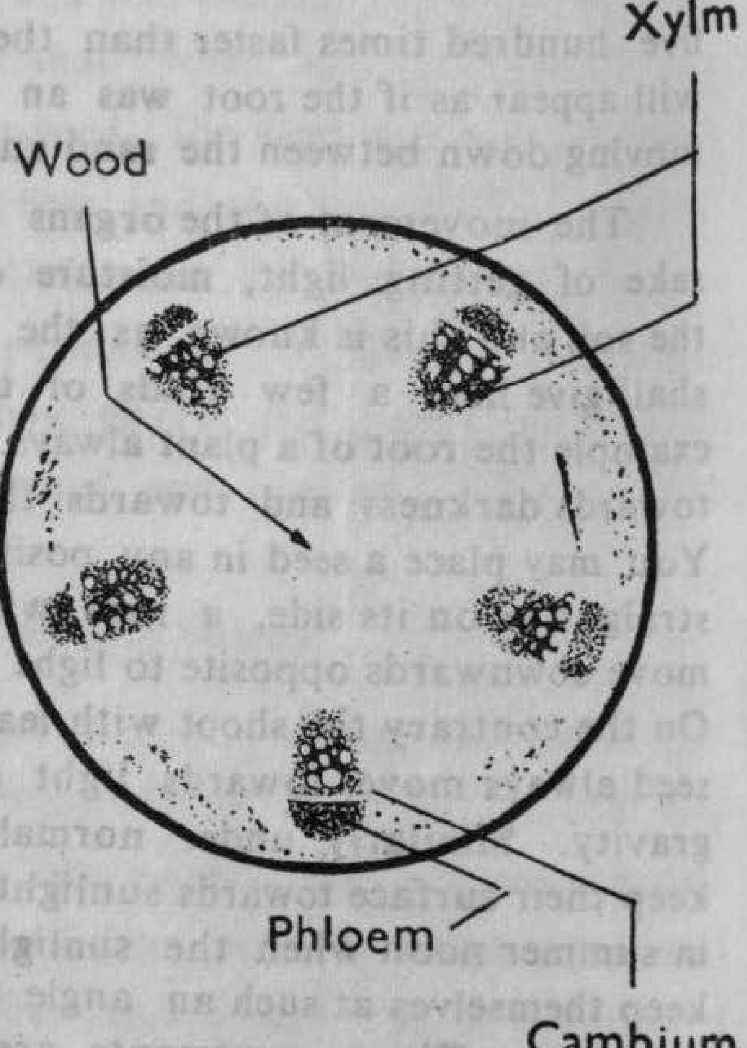


Fig. 3.1
In the stem there are separate passages for the salt solutions and manufactured food.

These two-way passages go from the stem to the larger branches, from here to the smaller branches and then from smaller branches to the leaves. When water and salts reaches the leaves through one of the passages and combines with sunlight and chlorophyll, it take the form of food, which is distributed to the different parts of the plants. (According to the ordinary laws of traffic) the food is taken along the second passage. In the middle of the passages there is present a wall known as the Cambium which has the capacity to grow. Due to the annual growth and spreading of cambium, the passages for the traffic of water and food go on separating from one another and the stem grows in girth. The passages of water and salts form the wood by becoming hard and the passage of the food which is under the bark remains soft.

3.7. Vegetative Reproduction

Plants like the animals also make out some plan to continue their generation. Some plants reproduce by means of seeds and there are some in which the reproduction is by means of vegetative parts. Reproduction by seeds starts from flowers. You must have read that stamens are situated inside the coloured petals of flowers which produce a large number of pollen grains or the male cells. Inside the circle of stamens there is one ovary or more ovaries inside which are present ovules or female cells. Then through some means like insects, air or water the male cells reach the ovaries and the ovules and by their union ultimately a seed is formed. The seed falls to the ground and grows into a new plant under suitable conditions. This method of reprodnction is known as the *sexual reproduction.*

There are a large number of plants which can continue their generation without the production of seeds. This method of reproduction is known as the non-seed method or vegetative reproduction. You might have sometimes seen the cultivation of sugar cane. On the node of every piece there are present some closed buds. Farmers cut the bud bearing pieces of sugar-cane and place them under the surface of the soil. New shoots arise from these buds which give rise to a new plant of sugar-cane. Cultivation of potato is also done in the same way The reproduction in grass is somewhat different. A shoot from a plant of grass runs parallel to the surface of soil and after covering some distance develops new roots there. Above these roots new, vertical, green shoots come out. If a shoot which is running parallel to the surface of the soil is cut or gets broken by itself, the new roots and shoots that had developed give rise to independent plants. In somc cases new plants are formed if old roots and leaves are sown under the surface of the soil. Similarly grafting in mangoes is also a method of vegetative reproduction. To conclude, there are organs other than seeds in plants from which new plants can be formed. By these methods the reproduction of plants becomes more sure. There is another advantage of vegetative reproduction in that a good breed can be kept absolutely pure. In the process of the formation of flowers and seeds there is always a danger of the mixing up of a good breed with a low breed thus giving rise to a low breed. Therefore in some fruit plants preference is given to the method of vegetative reproduction.

3.8. Advantages of Trees and their Protection

Man gets many advantages from the trees. Here only a few common advantages will be descirbed. Firstly the air for our respiration is kept clean and pure only in the presence of trees. The trees go on adding fresh oxygen to the air and go on absorbing the carbon dioxide which is produced by the animals. If the trees do not perform this function the air would not be fit for our breathing. Secondly all our food like wheat, rice, pulses, vegetables and fruits is produced by plants. Some people may object that meat, milk, butter and eggs are not produced by plants but a little reflection will show that sheep, cow and hens after all eat vegetable food and produce meat, milk, butter and eggs. Therefore it would be correct to say that plants are everything for us. Thirdly our clothes are made of cotton, jute and flax. Although it is true that some of our clothes are made from wool and silk but a common man cannot afford it. Fourthly bacteria and fungi which are also plants help in decomposition of the bodies of dead animals and plants and make them fit for use of the living objects again. If the bacteria and fungi are not there, the dead bodies of animals and lage stems of plants would remain as such and it woud become very diffcult for human beings and animals to live. In the end the flowers, shrubs, plants and grass are the torch bearers of beauty and peace in our world.

3.9. The Fungi

We know that all plants have chlorophyll in them with which they are capable of manufacturing their own food but some plants like the fungi are such that they do not have chlorophyll in them and get their food from other organisms. If they get their food from a living body they are known as *parasites* and if they get their food from the body of dead organism, they are known as saprophytes. A good example of parasitic fungi is the rust which destroys the crops. There are many other kinds of fungi which destroy sugar cane, potato, and grapes. Some of these even reach the human beings for example the ringworm on our skin is caused by one of the fungi. Saprophytic fungi are more common. Fungus that grows on pickles and bread is one of their example. Some fungi even do not spare the wood and other articles in buildings.

But this should not be understood that the fungi is only harmful to us. They have many advantages. The biggest advantage is that they change the dead bodies of animals or plants into such fine parts as urea and carbon dioxide which are once again used by the living objects. As it has already been described that if they do not function there would be piles of dead bodies around us, if there were no fungi.

3.10. Yeast and Bacteria

One kind of fungi are those one-celled plants which are known as yeast. When cells of yeast act on some organic matter, they produce carbon dioxide or alcohol or some other compounds *e.g.*, if bread is not made from the dough immediately and it is left as such for some time the yeast cells from the air enter and bring about an action and produce in it carbon dioxide. Carbon dioxide causes the dough to swell up and the bread which is prepared from it is known as the fermented bread. When it is desired to bring about an early fermentation of dough, a little yeast is added to it. So in the preparation of buns and bread the help of the action of yeast is taken. Similarly if the juice of sugar-cane or grapes is left over open and uncovered or a few yeast cells are added to it then, carbon dioxide alongwith alcohol is produced. In some Non-Muslim countries wine is prepared from this alcohol.

Bacteria are also one celled fungi but they are so small that in one square millimeter area one thousand individuals of bacteria can be placed side by side. Some of them cause typhoid tuberculosis and diphtheria, otherwise most of the bacteria do not cause disease. Another important thing about bacteria is that its cell divides very rapidly. Generally one bacterium divides into two bacteria in twenty minutes *i.e.*, in one day trillions of bacteria can be produced from one bacterium. It can be well imagined that if some dangerous type of bacterium enters the body of a living organism and its growth is not checked, then how rapidly it will spread.

Common type of bacteria cannot withstand severe heat, severe cold and strong light and die. Doctors sterilize their injection needles and get rid of bacteria before injecting by washing in hot water. However there is one condition of bacteria in which they draw a wall round themselves and are known as 'Cysts' or Spores. In this condition they become so much protected that they are not killed even in fifteen or twenty minutes at a temperature of 120° centigrade and under very high pressure, Their power of bearing cold is so much that they can live for six months at a temperature of — 190° Centigrade.

3.11. Mushrooms

During the rainy season you must have seen mushrooms growing in deserted places. Mushrooms are in fact the exposed portions of the saprophytic fungi, spreading inside the body of a dead organism like a web. They taste like meat and people eat it with great fondness. Some of their kinds grow into the stems of big trees and within a few years make them hollow from inside.

EXERCISE

1 What is the difference between the taking in of food by plants and animals?

2. What is photosynthesis ? What conditions are necessary for this process?

3. Why the plants give out oxygen during the day time and not at night ?

4. How does the water absorbed by the roots reach the leaves ?

5. What is Hybridization ? Give an example of hybridization.

6. What is Tropism? Give two examples of tropic movements.

7. What are the advantages of protection of trees to man ?

8. Describe the different methods by which plants reproduce themselves.

4

Astronomy

The Sun and the Solar System

You have studied in the previous class that the earth and eight other planets revolve around the sun in different orbits. One or more moons revolve around some planets. They are called the satellites of planets. The sun, planets and their satellites form a family known as the *solar system.* Now we shall explain what forces compel the planets to go around the sun and why the satellites have to revolve round their planets.

4.1 Gravitation, Intertia and Orbit

The famous scientist, Newton, was the first to tell that all bodies in the Universe have the property of attracting one another. This property is called *gravitation.* The force of attraction between the bodies depends on their masses and the distance between them. The greater their masses, the greater is the force of attraction, and if the distance between two bodies is less, the force of attraction is greater. The attraction due to gravitation acts on the earth, moon, sun, planets and all other things, big or small. Now the question arises why the earth, moon, sun, etc. do not pull and crash against one another due to the gravitational attraction.

Newton also found a few laws of motion of the bodies to solve this problem. One of these laws tells us that if a body is in motion and there is no force acting on that body, it will continue to move with uniform speed in a straight line. This property of matter is called inertia. When you roll a ball on a smooth surface, it moves in a straight line but it stops at some distance. This does not mean that the law of inertia has been disobeyed. It only means that some force has acted on the ball to stop it. This force is due to friction between the ball and the ground and the resistance of the air and it ended the inertia of the ball (that is, its property to keep on moving). If there was no friction etc. the ball would never stop.

Let us now find a reason for moon's motion round the earth. Due to the law of inertia stated above the moon

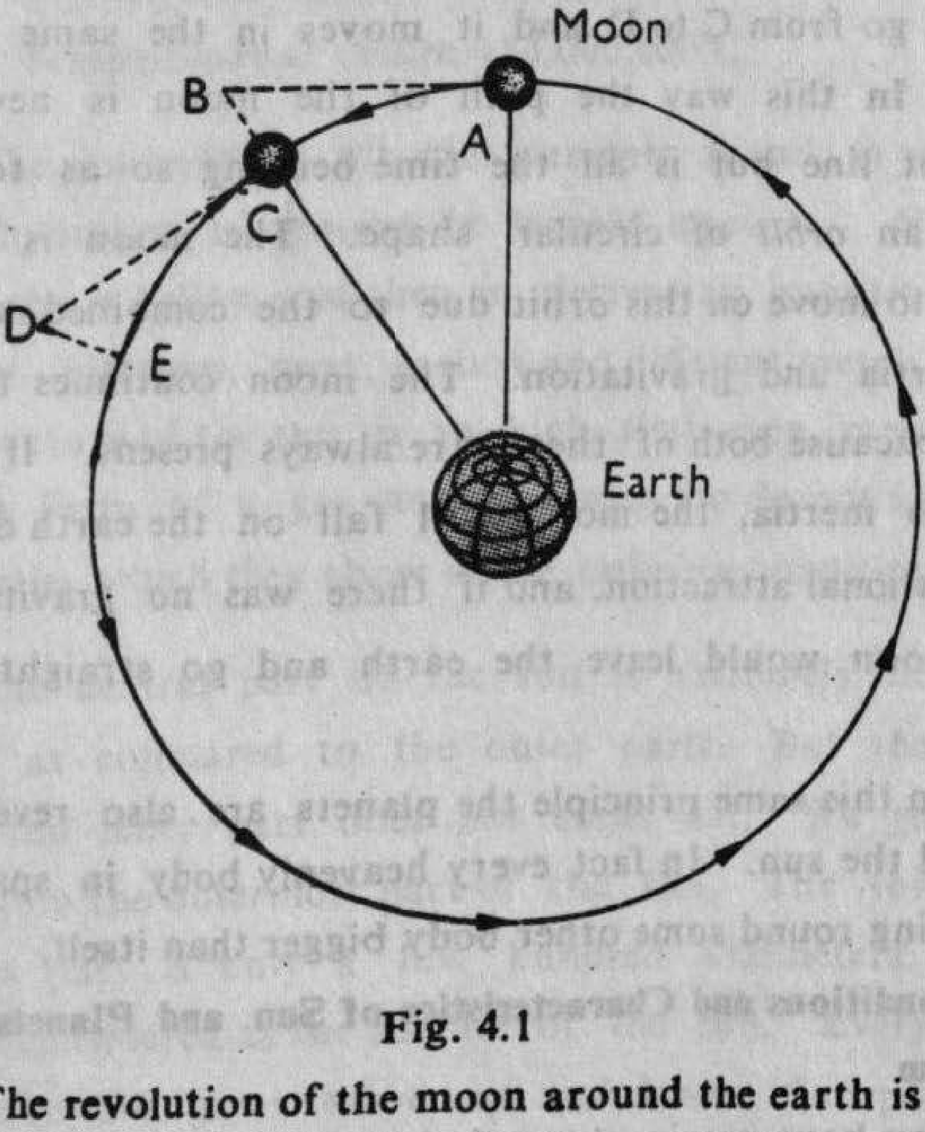


Fig. 4.1

The revolution of the moon around the earth is maintained by the combined action of inertia and gravitation.

should be moving in a straight line. That is, in Fig. 4.1 the moon should go from A to B. But we know that there is also the gravitational attraction between the earth and the moon. It prevents the moon to go towards B and pulls it towards the earth. It makes it go from A to C along an arc of a circle. Similarly the moon cannot go from C to D and it moves in the same circle to E. In this way the path of the moon is never a straight line but is all the time bending so as to become an *orbit* of circular shape. The moon is compelled to move on this orbit due to the combined action of inertia and gravitation. The moon continues to revolve bacause both of these are always present. If there was no inertia, the moon will fall on the earth due to gravitational attraction, and if there was no gravitation, the moon would leave the earth and go straight into space.

On this same principle the planets are also revolving around the sun. In fact every heavenly body in space is revolving round some other body bigger than itself.

4.2 Conditions and Characteristics of Sun and Planets

The Sun

You have previously read about the sun. The following facts and figures about the sun should be noted and remembered :

Distance from the earth—149,668,992 Kilometers

Sun's diameter =1,392,082 Kilometers

Volume =1,300,000 times as big as earth

Surface temperature =6,000°C

Temperature at centre=13,000,000°C

The sun contains all the elements found in nature, but hydrogen is present in largest amount. Next to hydrogen is helium and then in decreasing quantities are oxygen, nitrogen, neon, carbon and different metals. The temperature of the sun is so high that even metals are in the form of a gas and the gases too do not have the properties which they show under ordinary conditions.

The central part of the sun is extremely hot and bright as compared to the outer parts. But the light from the inner part does not come out. We get light only from the outermost part of the sun. The thickness of this part is only a few hundred kilometers. This part is considered as the surface of the sun. Everywhere in it the hot gases move up and down. Sunspots also appear on this part from time to time. The temperature in sunspots is about 4,000°C

The Planets

The planets are very small bodies as compared to the sun. It is believed that many thousand million years ago the sun and the planets were formed out of a large cloud of gas. The planets began to revolve around the sun from the very beginning. With time they cooled and formed their solid outer crusts. The smaller pieces of the gas cloud condensed to become the moons of the nearest planets.

The planets are listed in the table on page 67 in order of their distances from the sun. Important particulars of the planets are also given in this table.

Name of the planet	Distance from the sun in kilometers	Diameter in kilometers	Period of revolution round the sun	Period of rotation	Temperature	Number of moons
Mercury	57,936,384 km	4828 km	88 days	59 days	400°C	0
Venus	107,826,048 km	12231 km	225 days	249 days	430°C	0
Earth	149,668,992 km	12734.7 km	365¼ days	23 hrs. 56 mins	average 16°C	1
Mars	1½ times that of earth	6759 km	687 days	24 hrs. 37 mins.	average---50°C	2
Jupiter	5 times that of earth	143231.6 km	12 years	9 hrs. 50 mins.	—130°C	12
Saturn	9½ times that of earth	120700.8 km	29 years	10 hrs. 14 mins.	—150°C	10
Uranus	19 times that of earth	46670.9 km	84 years	10 hrs. 45 mins.	less than—160°C	5
Neptune	30 times that of earth	5793.6 km	165 years	16 hrs.	,, ,, ,,	2
Pluto	40 times that of earth	45061.6 km	248 years	about 6 days	,, ,, ,,	0

There are many tiny planets which revolve in the space between the orbits of Mars and Jupiter. These are called the *asteroids*. They can only be seen through a telescope. The biggest asteroid has a diameter of less than 805 kilometers. The scientists believe that there was perhaps a planet between Mars and Jupiter. For some reasons it broke into small pieces at some early stage. These pieces became the asteroids.

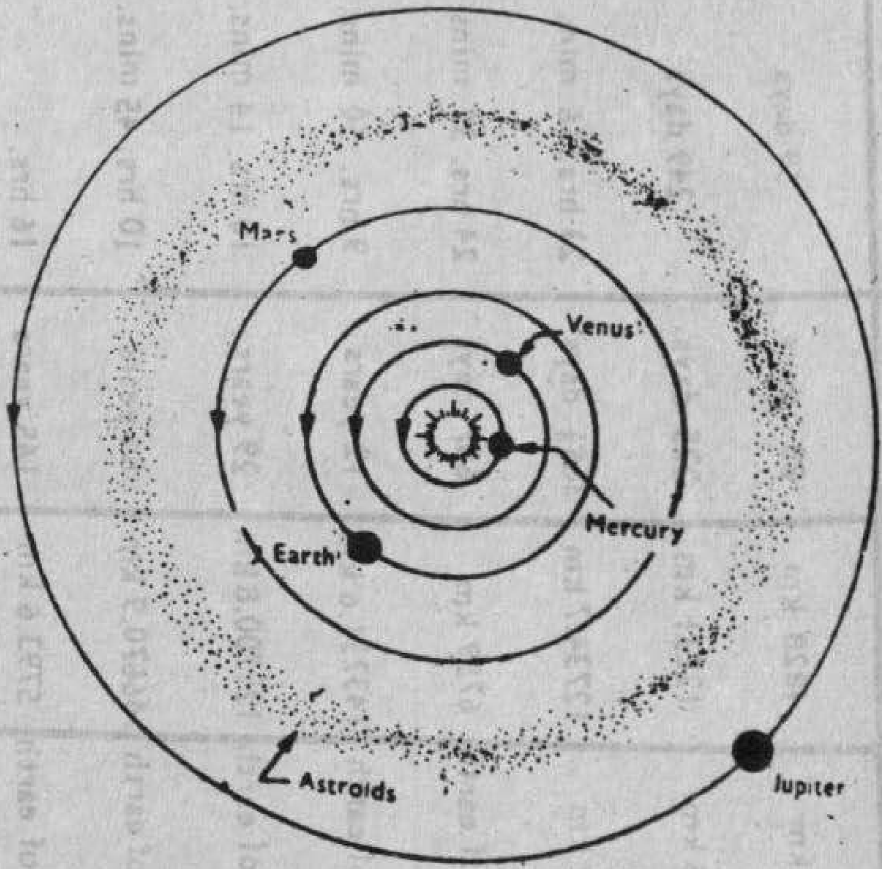


Fig. 4.2
There are many tiny planets between Mars and Jupiter. They are called the asteroids.

4.3 The Interior of the Earth

The interior of the earth consists of many layers. The outermost layer is called the *crust* of the earth. Its average thickness is 35.3 kilometers. This layer is made up of soild rock. The depth of sand or soil on the plains of the earth is only a few meters. Deep below the soil, and under the rivers, lakes and oceans, there is nothing but solid rock.

There are two main types of rocks in the crust. They are the *granite* (gra-nit) and the *basalt*. The light coloured granite rocks are found under the continents. Basalt rocks are very hard and are of a darker colour. They are found under the ocean floor as well as under the solid rocks of the continents. (Fig. 4.3)

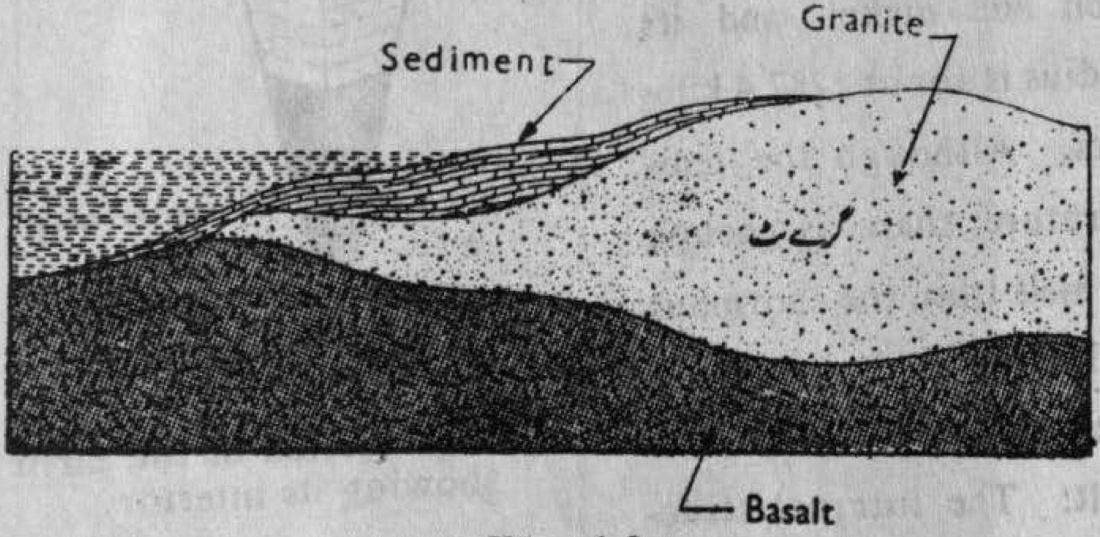


Fig. 4.3
Two types of rocks are found in the earth's crust, Granite and Basalt

The scientists think that there is another solid layer about 2896.8 kilometers thick under the crust. It is called the *mantle*. It consists of very heavy material but we do not know its exact nature. Man has not yet been able to drill a hole as deep as the mantle and take out the sample of material from there.

The part of the earth inside the mantle is called the earth's *core*. Its outer layer having a thickness of about 2253 kilometers, is of molten iron and nickel. The inner core is of solid iron and nickel and its radius is about 1287.4 kiloters. Although the temperature there is enough to melt iron, the enormous weight of the layers above prevents the iron there to melt: The internal structure of the earth is shown in Fig. 4.4

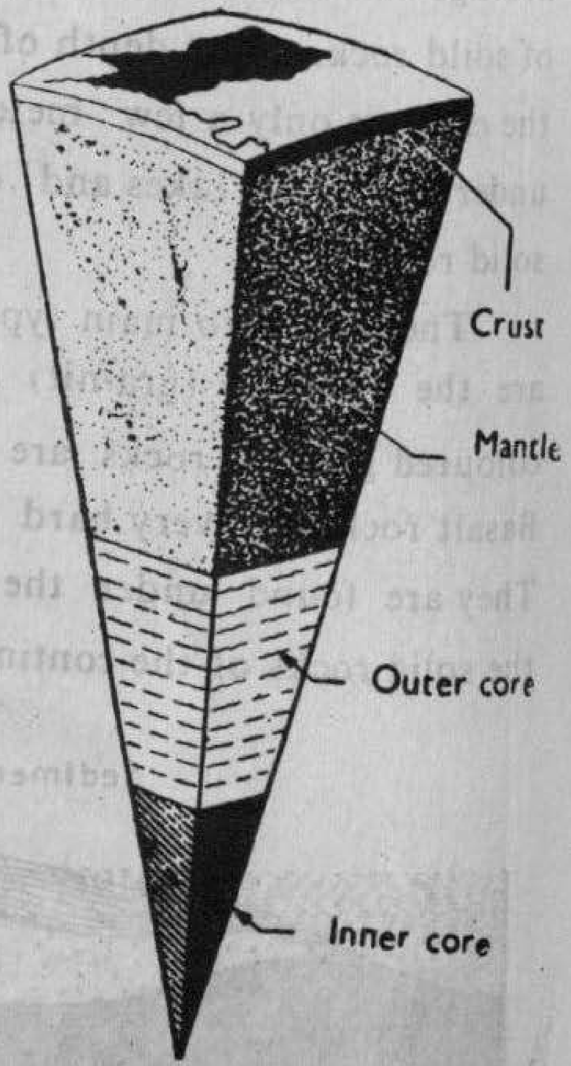


Fig. 4.4
A conical section of the earth showing its interior.

4.4 The Moon

The moon is a barren and lifeless heavenly body. There is no air and no water on it. Its surface contains sand and rocks. The moon has a number of deserts,

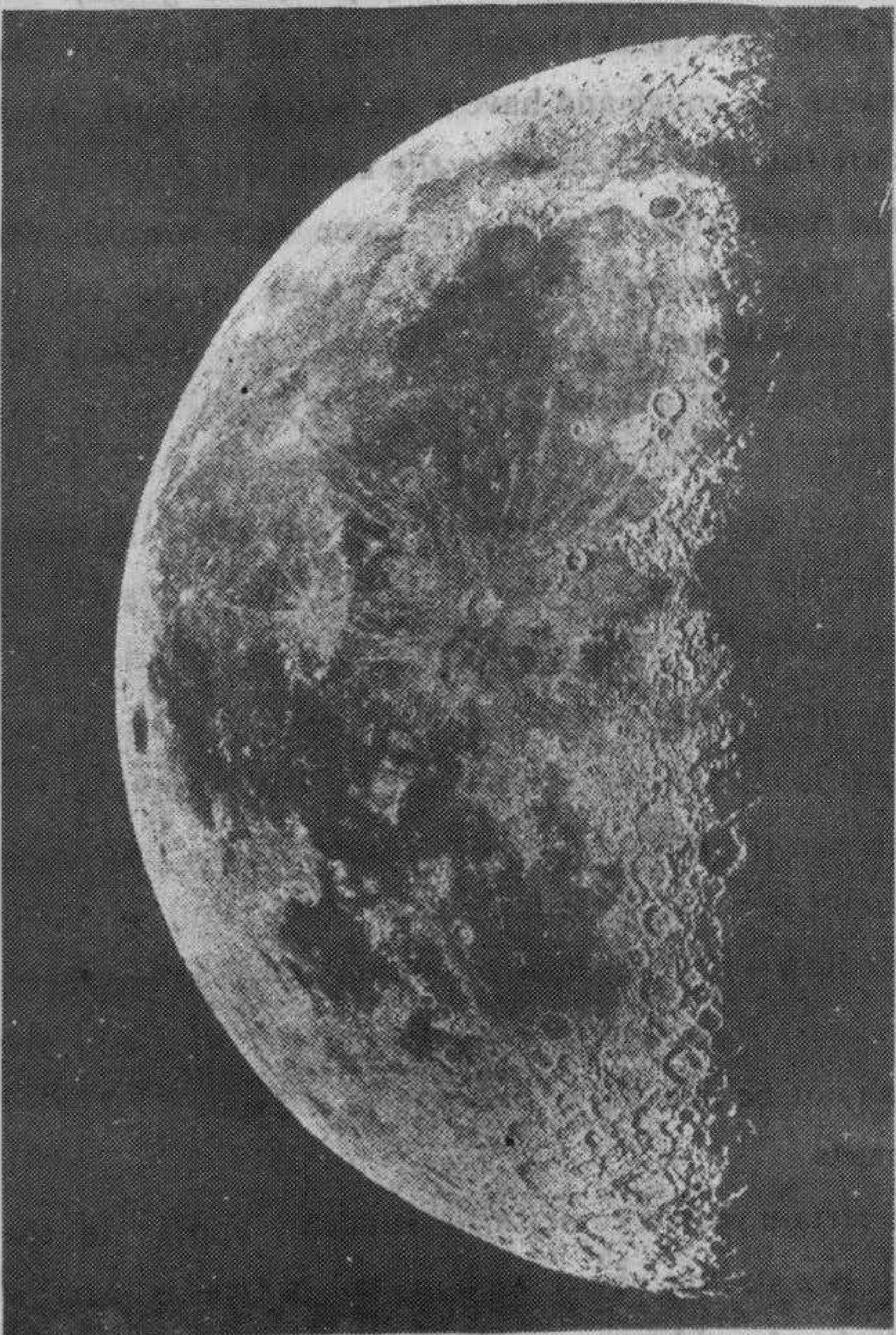


Fig. 4.5

mountains and many pits or *craters*. The moon's craters can be seen clearly through a telescope, (see Fig. 4.5).

The soil and rocks brought from the moon by the astronauts are rough and have a brownish colour. Such rocks are found in volcanoes on the earth.

The moon always turns the same face towards the earth. This is because the moon rotates on its axis in exactly the same time as it takes it to revolve around the earth. Thus the far side of the moon is always out of our sight. The astronauts who have orbited around the moon have obtained pictures of all parts of the moon including the far side. These show that the far side has no plane areas but is full of craters.

The day on the moon is of two weeks duration and the night is also of the same length. This causes a big difference in the day and night temperatures. At noon the moon's temperature is more than 100°C and at night it falls below—150°C. Since the moon has no atmosphere, the sky looks totally dark even during the day and the stars can not be seen in the presence of the sun.

4.5 Comets

In certain years a comet may suddenly appear in the sky. It is a starlike object with a tail which is narrow near the head and becomes wider away from it. A comet is usually visible for eight or ten days or at the most for some weeks. After this it disappears. Some ignorant people think that comets have evil effects, but this is a wrong belief. The comets have nothing to do with any calamity or misfortune of our world.

The comets also belong to the solar system. They revolve around the sun in very large oval orbits. The bigger the orbit, the longer is the time of revolution. Most comets revolve around the sun in more than fifty years and some take centuries to make one revolution.

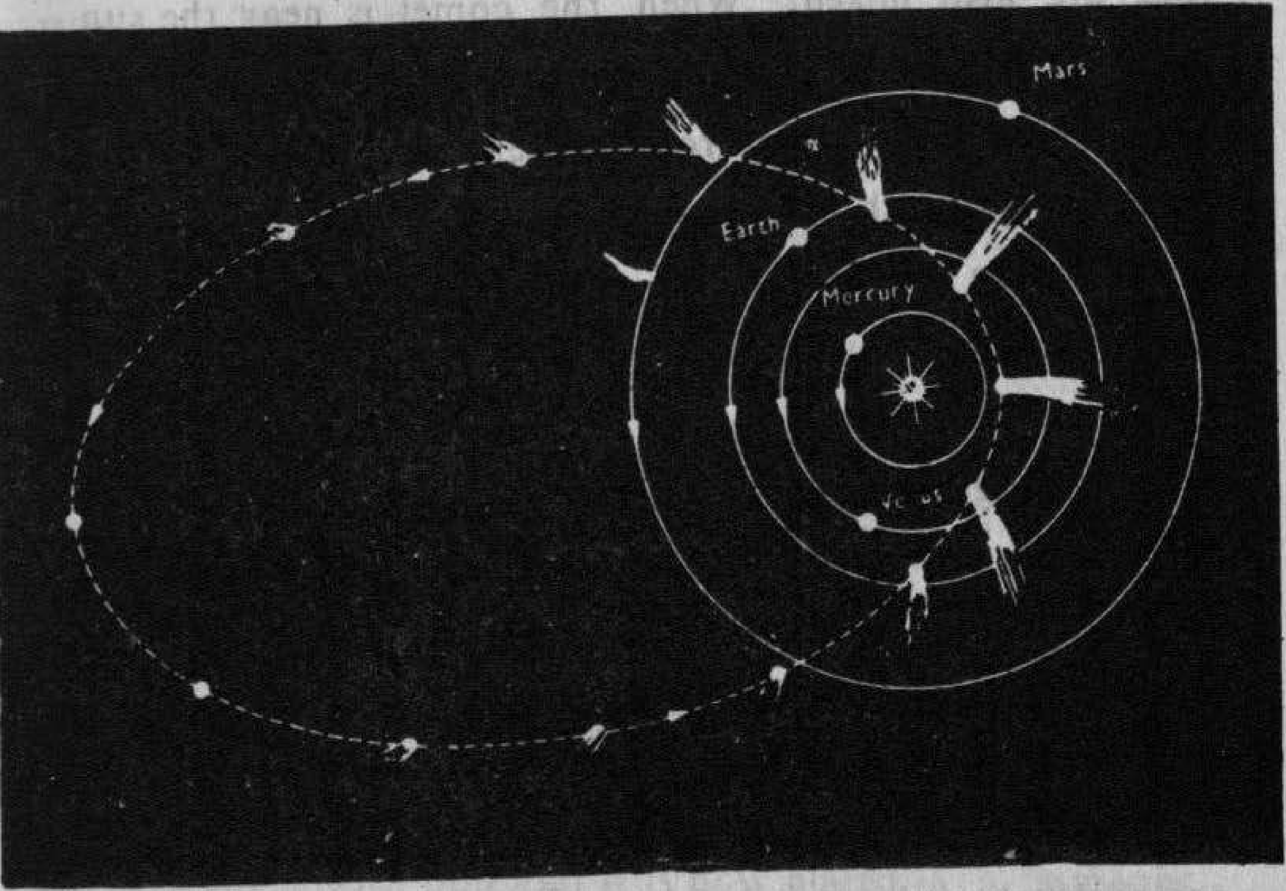


Fig. 4.6
A comet moves in a long oval orbit around the sun,

We see a comet only when it comes nearer the sun and the earth. At that time it looks brighter and has a longer tail.

Only the inner part of the comet's head is solid and its diameter is from one to two kilometers. This part is made of ice in which many particles of iron and bits of rock are also mixed. When the comet is near the sun some of the ice is changed into steam due to heat and it spreads as a huge cloud round the head. Now light has a property to push the matter particles on which it falls, so the strong rays of the sun push the solid particles and the gases in the cloud away from the head. In this way the tail of the comet is formed, the nearer a comet is to the sun, the longer is its tail. Many particles are pushed out of the tail and are detached from the comet, but they continue to follow the comet on the same orbit. We shall talk about them in the following article.

4.6 Meteors and Meteorites

We often see a "shooting star" at night. As it moves across the sky it leaves a bright trail and then disappears at some distance. The name shooting stars for these objects is rather wrong. In fact they are not stars at all. In science we call them *meteors*. They are merely dust particles and grains of rock or metal that dash through the atmosphere.

Dust particles and larger pieces of metal, which are ejected from the comets, as mentioned above, keep revolving around the sun. They are countless and are roaming everywhere in the solar system. Our earth is being hit by them at all times. The speed of a meteor near the earth may be from 12.9 kilometers to 72.421 kilometers per second. When a solid particle enters the atmosphere with this great speed, the friction with air heats it so much that it burns out and is destroyed before reaching the earth's surface.

If, however, the meteor coming towards the earth is a big rock or piece of metal it cannot burn out and finish itself completely in the air. It falls on the earth violently. Many such rocks have been discovered in different places. They are called *meteorites*· A large number of them are made of two metals, iron and nickel. The biggest meteorite found so far, is lying at its place of fall in south west Africa. The second biggest single meteorite was found in Greenland by the American explorer, Peary, in 1894 He brought it with him and it is now placed in a museum in New York, U.S.A. This meteorite weighs 3,553,244,8 kilograms.

On the 30th of June, 1908 many meteorites fell in a forest in Siberia. All trees in that area, about 64.374

Kilometers in diameter, were either burnt or uprooted. Many craters were formed in the ground, the largest of them being 45 meters wide. Again, on 12th February 1947, a large meteorite hit another part of Siberia. It broke into many pieces before falling on the ground. The total weight of the pieces of that meteorite must have been about 104,50 7,200 Kilograms.

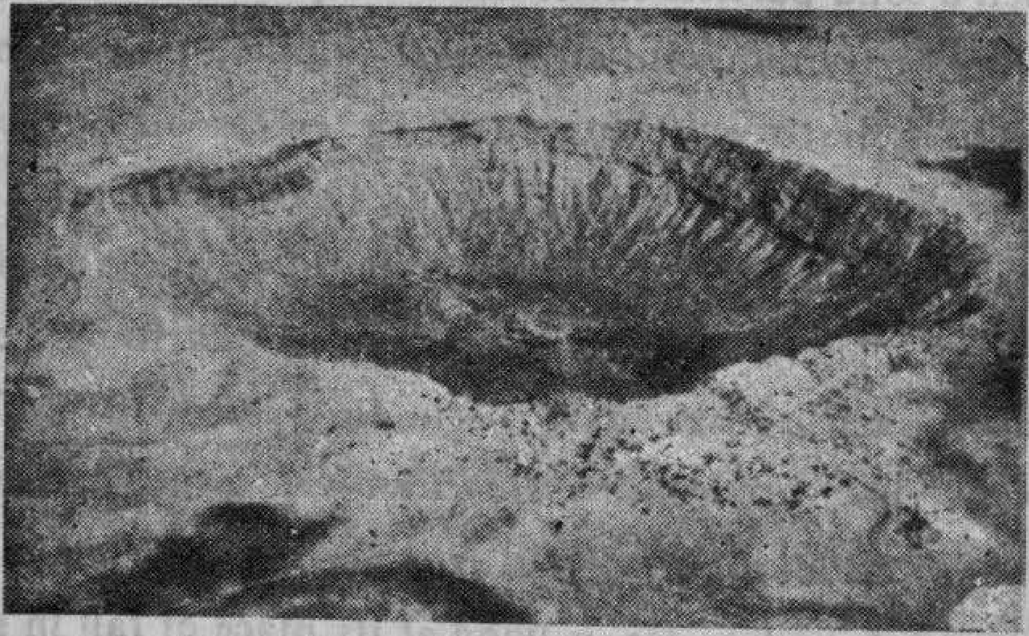


Fig. 4.7
Meteorite crater in Arizona.

There is a crater about 180 meters deep and 1.2 kilometers wide in a desert in Arizona. U.S.A. It is believed that an enormous meteorite fell here about 50 thousand years ago. The greater part of the meteorite was blown up into sand and bits of rock which scattered over an area of many square kilometers.

4.7. Life on other planets

You know that suitable amounts of light, heat, air, water and food are required for life. The air should contain oxygen for animals and also carbon dioxide for plants. Let us now examine whether or not these things are present on some planets other than the earth and whether there are living beings of any kind on another planet.

Mercury and Venus are closer to the sun than the earth and therefore they are very hot. On Mercury the temperature at noon is 400°C and on Venus also the temperature has been found to be nearly as much. For this reason alone life on these two planets is not possible. On the other hand Jupiter and all other planets beyond it are extremely cold. Their temperature is below—130°C. On these planets too life in any known form is not possible

There remains only one planet which is Mars. Although it is very cold as compared to the earth and the temperature of its greater part is less than—60°C, yet the areas of the planet near its equator are warmer. The next problem with Mars is that of air. There is not much air on this planet and there is hardly enough oxygen in that air. Ice can be seen near the poles of Mars but the rest of the planet seems to be dry and barren. There are, however, some areas on which we see green and brown markings. These are supposed by some scientists to be some lower forms of plants but there is no hope to find animals on Mars.

Outer Space

4.8 Stars

On a dark clear night we see many stars shining like diamonds in the sky. About 6000 stars can be seen over the whole sky. If we watch carefully we will see that stars keep moving slowly all night from East to West. As time passes, some stars set in the west and some other stars rise in the East. It should be noted that this motion of stars is only apparent. In fact it is the rotation of the earth on its axis which shows the sky as if it were moving. Due to this the stars appear to be moving in different circles.

The sky looks like a great dome on which the stars are tucked. They all seem to be at the same distance from us but actually their distances are different. Faint stars are usually too far off as compared to those which look brighter.

The name of the nearest star is Alpha Centauri. It is 3218688 kilometers away from the earth. Distances of stars are generally measured in *light years*. A light year is the distance which light travels in one year and it is about

965606 Kilometers. Thus the distance of Alpha Centauri is four and a quarter light years. Other stars are still farther away. We can observe stars thousands of light years away through big telescopes.

Astronomers have found that stars, like our sun, are very big and luminous bodies, some of them are even bigger and hotter than the sun. They look like dots because they are so far off.

4.9. Constellations

People in early times thought of an interesting way to identify stars. In children's magazines you must have seen a puzzle in which many points are marked. When these points are joined together, the figure of an animal or some other object is drawn. In the same manner the Greeks first made several imaginary pictures on the sky by joining the brighter stars with one another. They imagined pictures of human beings, animals like bears, snakes, lion, scorpion, etc., or non-living things and then they showed them on charts of the sky. They used to recognize stars with the help of these imaginary pictures.

The groups of stars forming these pictures are called *constellations.* The word constellation means a group of stars. Later on Muslim scientists gave names to bright stars in various constellations. Some examples are Altair, Aldebaran, Fomalhaut, etc. These and many other stars named in arabic are still in use as such.

The men who study the stars have not, uptil now, changed the arrangement or names of constellations; but the old practice of drawing complete pictures has been given up. Only simple diagrams of constellations are now drawn, as is shown in Fig. 4.9. The constellation in Fig. 4.8 and 4.9 is called *scorpio* (the scorpion). In Fig. 4.8 it is shown as it was drawn on maps in old times. We can see the constellation of Scorpio during the summer months at about 9 or 10 p.m. towards south.

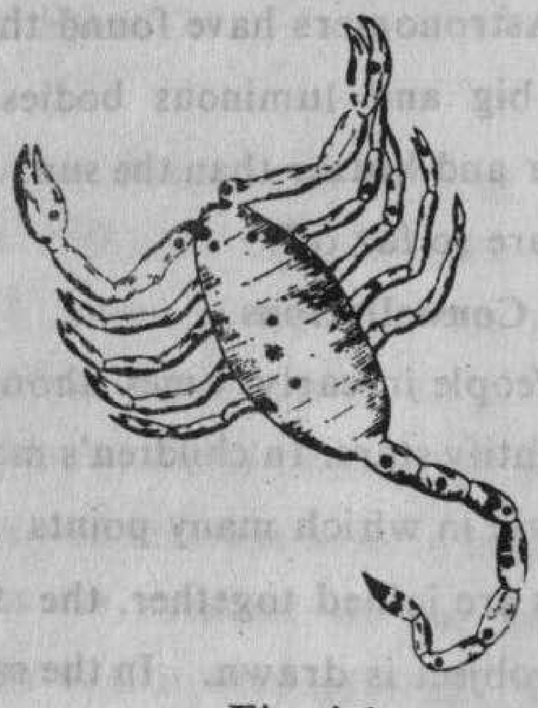


Fig 4.8
The constellation of Scorpio.

Another well-known constellation is *ursa major* (the big bear), which can be seen in summer high up on the sky towards north. Its seven bright stars can be easily recognized. If the first two stars in this constellation are joined by a line and this line is produced forward you will be able to see the pole star a little further in that direction. Ursa Major helps you to find the pole star easily.

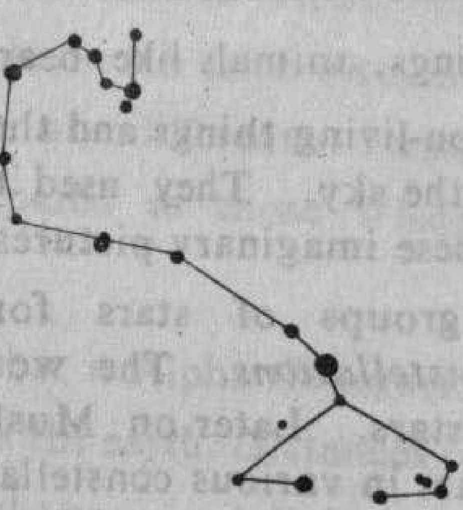


Fig. 4.9

4.10. Galaxies

In summer nights you might have seen a path of faint light stretched across the sky. It is called the *milky way*. If we observe more carefully, we find more stars in and around the milky way than in other parts of the sky. Photographs taken with the help of big telescopes show that there are countless stars in the milky way, but they are so far off that our naked eye is unable to see them as separate stars. Their combined light, however, reaches us and we see as if there was a band of luminous fog or smoke across the sky.

After years of observation and thinking, the astronomers have found that all stars, which we can see with the naked eye or the telescope, form an enormous system called the *galaxy* or *galactic system*. It has a flat circular shape and is somewhat like the wheel of a horse cart, that is, it has more thickness in the middle than near the rim. Our sun, alongwith its planets, is situated some distance away from the centre of this system.

If we could go out of the galaxy and looked at it from a distance we would see it.

Our galaxy has a diameter of about 100,000 light years and its thickness at the centre is 10,000 light years. There are about a hundred thousand million stars in it. Try to imagine how big is the Galactic System.

Outside our galaxy there are no other bodies up to great distances, but about 2 million light years away there is another galaxy, of almost the same shape and size and containing nearly the same number of stars as in our own galaxy. It is so far off that it looks merely as a faint spot of light. It is not possible to see its separate stars even in large telescope, but we can see its shape like a whirling cloud.

Still farther off there is another galaxy, then another and so on. There are great many of them at increasing distances. The farther a galaxy from us, the smaller it appears to be. Their number is in millions. They do not seem to end anywhere and they extend into space as far as we can observe with our biggest telescope. The universe, created by the Almighty Allah, is so vast and big that we are lost in wonder when we try to perceive it. How tiny is our earth in this universe !

4.11. Astronomical Instruments

For good observation of the heavenly bodies we need a telescope. There are two types of telescopes used in astronomy, One is the *refracting telescope* and the other is *reflecting telescope.* The refracting telescope is fitted with lenses. Its principle and working will be described in the chapter on light.

The important part of a reflecting telescope is a concave mirror which collects the rays of light from the heavenly body and forms its image. In astronomical work the reflecting telescope is found to be better and more useful.

The telescope of either type is mounted on a firm support in such a way that it can move in all directions and can be pointed towards any point on the sky. The roof above the telescope is in the form of a dome which can turn round on wheels. A slit opens in the dome and we see a part of the sky through this. By turning the dome the open slit can be placed in the direction of the sky to be observed. Large and heavy telescopes and their domes are fitted with electric motors which can turn them in any direction.

Instruments for taking photographs are also attached to the telescopes. Astronomers get fine pictures of the heavenly bodies and discover new things about them.

The place where telescopes are kept for observing the sky is called an *observatory*. The world's biggest refracting telescope is in Yerkes observatory in the U.S.A. Its lens is 1.2 meters in diameter. The biggest reflecting telescope, also in the U.S.A, is in Mount Palomar observatory. Its mirror has a diameter of 6.0 meters. Among the muslim countries, the Egypt has the biggest telescope with a lens of 2.22 meters.

SPACE TRAVEL

4.13. Landing of Man on the Moon

To think of going to the moon was considered foolish in the past, but in the twentieth century man has made this impossible task possible with his wisdom and courage The biggest hurdle in space travel was the earth's force of gravity. It was overcome when the Russians and the Americans made many experiments and invented rockets which could fly with a speed over 40233 Kilometers per hour. It has been found by mathematical calculations that if an object is thrown in any direction away from the earth with a speed more than 40233 Kilometers per hour, the object will never return to the earth. When this speed was achieved with rockets, preparations were made to go to the moon.

The Americans made a lengthy plan for landing a man on the moon. They named the plan as *project Apollo.*

It consisted of 20 flights from Apollo 1 to Apollo 20. Later they changed the programme so as to complete it with Apollo 17 flight. In earlier flights success was achieved in steps to make sure that man can be safely landed on the moon and then brought back on earth. In Apollo 9 and 10 flights the astronauts were sent very near the moon but they did not land, Their space craft orbited the moon and then came back. At last on 16 July, 1969 the Apollo 11 spacecraft left for the moon with three astronauts aboard. They were Neil Armstrong, Edwin Aldrin and Micheal Collins.

The spacecraft was placed on top of a huge 3 stage rocket, as shown in Fig. 4.11, When the rocket was fired, its lowest stage took it straight up to a height of about 64.374 kilometers. This first stage separated itself and fell down while the second stage pushed the rocket further in a slanting direction. When the fuel in the second stage was also burnt up, the speed of the rocket had become 28968 kilometers per hour. This was the right speed to put the rocket in an orbit round the earth.

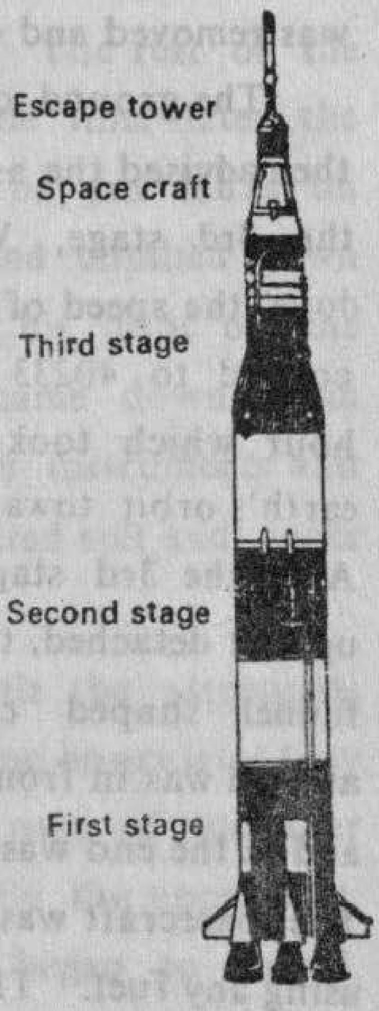


Fig. 4.11
The Apollo 11 spacecraft with three-stage rockets.

A small rocket, called the escape tower, was attached in front of the spacecraft. Its purpose was to return the astronauts at once to the ground if any fault occured in the rocket after launching. Now this was not needed, so it was removed and sent back to earth.

The ground contol centre then advised the astronauts to fire the 3rd stage, When this was done, the speed of the rocket increased to 40233 kilometers per hour which took it out of the earth's orbit towards the moon. After the 3rd stage was used up and detached, the spacecraft had these three parts ; the funnel shaped *command module* with the astronauts aboard was in front; behind this was the *service module* and at the end was the *lunar module* enclosed in the cover. The spacecraft was now speeding to the moon without using any fuel. The lunar module was taken out of the rear part and was attached in front of the spacecraft.

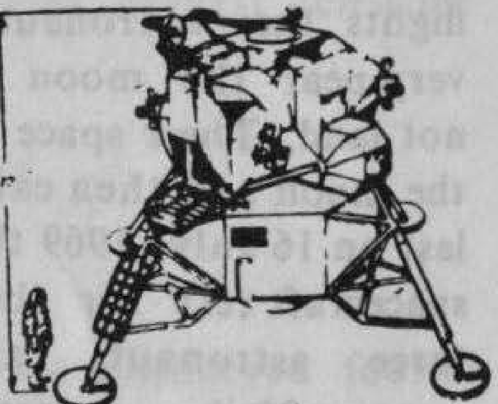


Fig. 4·12

Near the moon the speed of the spaceship was about 8046.7 kilometers per hour, it was further reduced so that it entered into an orbit round the moon. If it was not slowed down, it would have either crashed on the moon or would have passed by the moon into the outer space.

Then two astronauts shifted themselves to the lunar module and the third kept sitting in the command module. They started the engine of the lunar module to slow it down. It began to descend slowly towards the moon and at last landed softly on its four legs. The rest of the spacecraft remained in the orbit. Some time later the astronauts fitted their space suits with oxygen tanks on backs. Neil Armstrong first came out and climbed down the ladder. He was the first man to put his foot on the moon (on 21st July 1969). After him came down Edwin Aldrin. Then they brought down some instruments and did some experiments. They also collected soil and rocks from the moon.

After about two hours of work both the astronauts came back inside the lunar module. Some hours later they fired the engine. The lower stool-like part of the lunar module remained on moon's surface while the upper part, in which the astronauts were seated, began to ascend. This part of the flght was so perfect and correctly timed that the lunar module came up and rejoined itself with the spacecraft which was circling the moon. Both astronauts moved into the command module and met their friend Collins. The lunar module was then made to drop back on the moon.

The return journey began when the speed of the spacecraft was increased to move it out of the moon's orbit. As it came closer to the earth, it gained more speed due to earth's pull. The speed had to be brought down to accomplish the last and the most dangerous part of the flight, that is, safe landing in the sea. The command module with astronauts aboard was detached from the service module. These two began to fall towards the earth in different directions. On entering the atmosphere, the intense heat of friction with the air burnt the service module but the command module was made in such a way that frictional heat could not damage it. At a height of a few thousand meters the parachutes attached to the module opened and it fell at a known place in the Pacific ocean. The astronauts were picked up from there by a helicopter. Then the historical journey came to an end successfully.

The next trip to the moon was made by Apollo 12 in December 1969. Its two astronauts spent a longer time on the surface of the moon. The Apollo 13 flight in April 1970 was not successful due to a fault in the rocket. The lives of three astronauts aboard were put in danger but they were lucky to survive by bringing the spacecraft back on the earth

A few months later, Apollo 14 visited the moon. Then in 1971 Apollo 15 landed and its two astronauts spent 67 hours on moon. They travelled on moon's surface for many miles in a special car which they had taken with them. Views of the hilly surface of moon were shown on the earth with a television camera fitted on that car.

Apollo 16 was sent in April 1972 and with the flight of Apollo 17 in December 1972, the American programme of lunar flights came to an end. After this man will perhaps be able to set up a permanent laboratory on moon. It would contain automatic instruments which could be controlled from the earth. They will send us more and more information about the heavenly bodies.

The Russians have not sent any manned spacecraft on moon so far, but in 1971 they did another wonder by landing an unmanned spacecraft named Luna which was entirely cotrolled from earth. It collected soil and rocks from the moon and brought them back on earth.

4.14. Conditions to Live on the Moon

Man has reached the moon and the question naturally arises whether man will also be able to live on moon. You have read that there is neither air nor water on the moon and the temperature there can be too high or too low. In such conditions we cannot hope to go on moon, build houses and live in them happily

If a colony was ever to be planned on moon, it must be totally enclosed and there must always be enough oxygen inside at suitable pressure. A larger part of it should be built under a mountain to avoid too much of heat. Some of it should be outside with a cover of strong clear plastic so that we may see the view around us. There should be a factory to manufacture oxygen from rocks with chemical process. A pipeline should supply oxygen regularly from the factory to the colony. Arrangements to prepare water and food should also be made. A limited number of scientists, engineers and workers will then be able to live for a longer time in such a colony.

All this seems to be just imagination at present but some fifteen or twenty years ago the flight to the moon also appeared as a fairy tale. Who can say what new wonders of science we are going to see in the future? Yet there is not much possibility that big cities will ever be built on moon or a large human population would migrate there, as people of Europe had once gone to settle in America or Australia.

The time is still far off when man will plan to go to a planet. But, looking at the present progress, we cannot call this as impossible. If a spacecraft overcomes earth's force of gravitation, it would begin to move in an orbit round the sun. By controlling its speed and course it can be made to move on a path which should meet the orbit of another planet. Spacecrafts have thus been sent towards Venus and Mars and some of them landed there. They had no men aboard. A Russain spacecraft has been sent towards Jupiter also for making its observation from a close range.

There are at present many difficulties in sending a man to another planet. The two way journey to another planet is very lengthy and it requires big spaceships. Such a project can fail with a little error and the astronauts may not come back alive. Perhaps by the end of this century the scientists might be in a position to send a manned spacecraft to another planet.

At first, flights towards Mars and Venus will be attempted. These are our neighbouring planets and we wish to know more about them. For the time being we cannot think so much about visiting Jupiter, Saturn or other planets beyond them. There are problems which are difficult to overcome. Consider, for example, the surface gravity of Jupiter. It is about 2½ times as great as that of the earth. A spacecraft landing on this planet can hardly ascend again from it and come out of its gravitational attraction. The weight of an astronaut on Jupiter will also be 2½ times greater. It will be difficult for him to stand on his legs and carry his own weight.

QUESTIONS

1. There is gravitational attraction between earth and moon. Explain what prevents them to crash into each other.

2. Look up the table showing particulars of the planets and tell:

   (a) Which is the planet nearest the sun?

   (b) Which is the biggest planet?

   (c) Which planets do not have satellites?

   (d) Which planet has neither too high nor too low temperature?

   (e) Which planet rotates fastest on its axis and which one rotates slowest?

3. Describe briefly the interior of the earth.

4. Describe the surface of moon. There is a big difference in Moon's day and night temperature. What is the main reason for it?

5. How is the tail of a comet formed?

6. What is a meteor? How does it shine?

7. What are constellations ? Name any constellation.

8. Write a short note on our galaxy. What is the diameter and number of stars in the galaxy?

9. How many astronauts went on the first flight to moon and how many landed? Tell the name of this flight and names of its astronauts.

10. Fill in the blanks in the following sentences so that they give correct scientific statements. Pick suitable words at the end of sentences to fill the blanks :

(a) The countless tiny planets, revolving in the space between the orbits of Mars and Jupiter, are called——.

(comets, asteroids, meteorites)

(b) The moon keeps the same face towards the——.

(earth, sun)

(c) Comets are revolving round the——.

(galaxy, moon, sun)

(d) Meteorites are made of rock or——and——.

(iron, glass, gases, nickel)

(e) There may perhaps be lower forms of——on Mars but there is no hope to find animals.

(fish, plants, canals)

(f) The nearest star is named——.

(Alpha Centauri, Pole star, Mars)

(g) Through the telescope we can see a large number of——in the milky way.

(planets, constellations, stars)

(h) It is difficult for man to settle on moon permanently because there is no——and no——on it. *(light, water, mineral. air)*

5

Heat

5.1. Kinetic Theory of Heat

You know that all substances are made up of molecules. There are lacs and lacs of molecules in each substance and each molecule is either moving from one place to another or vibrating at its own position. Molecules possess kinetic energy due to their motion. The total kinetic energy of the molecules is equal to the quantity of heat in a body. Thus heat is a form of energy and it depends on the motion of molecules.

The motion of the molecules of a body is not uniform. The various molecules may be moving or vibrating at different rates from moment to moment. Fast moving molecules possess more energy as compared to slow moving molecules. The average kinetic energy of the molecules determines the *temperature* of a body.If the molecules of a body are in rapid motion or vibrating quickly, their average kinetic energy is more and its temperature will be high. On the other hand if the motion of the molecules is slow, the average kinetic energy of the molecules and hence the temperature is low. Thus there is an important relationship between quantity of heat and temperature. Heat is a form of energy—equal to the total kinetic energy of the molecules while the temperature depends on the average energy of motion of the molecules.

If a body is heated, the average kinetic energy of the molecules increases and the temperature is raised. Likewise, if the body is cooled, the energy of motion of its molecules is decreased. If the temperature of a body is decreased to —273°C, the motion of its molecules may disappear altogether. It is for this reason that this temperature (—273°C) is known as *absolute zero.* So far scientists have not attained absolute zero although they have managed to cool some substances to within a fraction of a degree of it.

5.2 Quantity of heat and temperature

You have already studied that the quantity of heat in a body is equal to the total kinetic energy of its molecules and its temperature depends on the average kinetic energy of its molecules. Now we shall consider some experiments which will further explain the difference between the quantity of heat and temperature.

Experiment. Take two similar glass beakers containing equal amounts of water. Place a stirrer and a thermometer, and note the temperature of the water in each beaker. The temperature of water in both beakers will, of course, be the same because water from the same tap has been used.

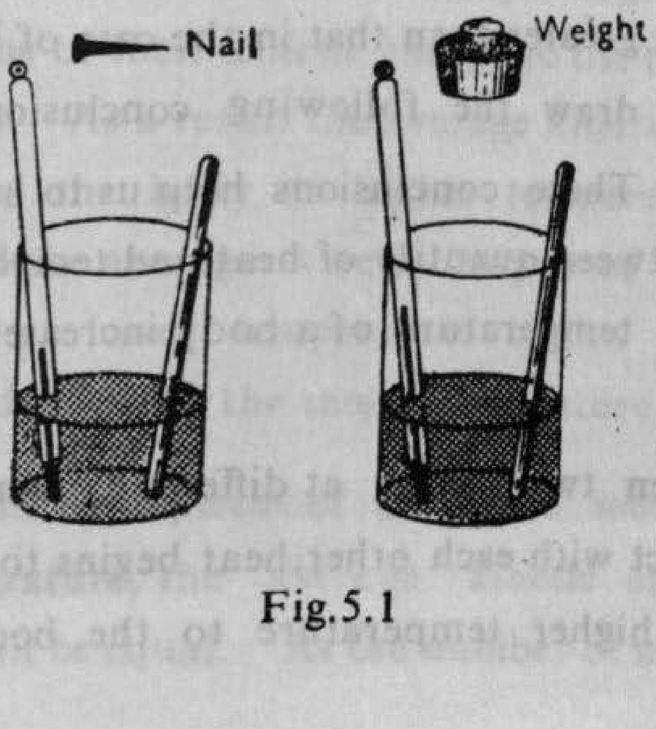


Fig.5.1

Hold a small iron nail in a pair of tongs and heat it in a flame until it is red hot. Now drop the red hot nail into one beaker and stir the water gently. Note the temperature of water when it becomes steady. You will see that temperature of water rises only a few degrees.

Now heat an iron weight of 100 grams until it is red hot. Put the red-hot weight in the second beaker and note the final temperature of water after thoroughly stirring it. You will see that the rise of temperature of the water in the second beaker is much higher as compared to that of the first beaker (Fig. 5.1)

In this experiment the temperature of the iron nail and that of the iron weight of 100 grams are almost equal, but the quantities of heat contained in them are different because the rise of temperature of water when iron weight is put in it is greater than that in the case of iron nail.

We can draw the following conclusions from this experiment. These conclusions help us to understand the difference between quantity of heat and temperature.

1. The temperature of a body increases when heat is given to it.

2. When two bodies at different temperatures are put in contact with each other, heat begins to flow from the body at a higher temperature to the body at a lower

temperature, until they attain the same temperattre.

3. A big piece of a metal contains more heat as compared to a small piece of the same metal even though their temperature is the same.

Now we consider the above mentioned conclusions in the light of kinetic theory of heat. When a body is heated, the motion of its molecules becomes fast. The average kinetic energy of the molecules increases and so the temperature of the body rises.

If two bodies are at different temperatures, the average motion of molecules of the body at higher temperature is faster than the average motion of the molecules of the body at lower temperature. When these bodies are put in contact with each other, their molecules collide with one another. The molecules of the body at higher temperature transfer some of their kinetic energy to the molecules of the second body. As a result the average kinetic energy of the molecules of the body at higher temperature starts to decrease and the average kinetic energy of the molecules of the body at lower temperature begins to increase till both the bodies attain the same temperature.

If two different pieces of a certain metal are at the same temperature, the average kinetic energy of their molecules will be equal. As the number of molecules of the bigger piece is comparatively large, so the sum of their kinetic energies will be more and hence it contains more quantity of heat.

5.3. Explanation of some Common Heat Effects on the Basis of Kinetic Theory of Heat

We know that when a body is heated, it undergoes some changes. For example a body may expand or it may change its state on being heated. We will now try to explain these changes on the basis of kinetic theory of heat.

Thermal expansion

When the temperature of a body is raised, its molecules start moving more rapidly and the kinetic energy possessed by each molecule is increased.

In the case of a solid or a liquid the molecules vibrate more energetically and so the distance between them increases. As a result they expand. If a liquid or a solid is cooled, their molecules vibrate less rapidly. The intermolecular distance decreases and the material contracts.

Whem a gas is heated, the motion of its molecules becomes rapid, causing them to travel greater distances before they can be turned back by collision with each other. The space taken by all the molecules—the volume of the gas—increases provided the pressure of the gas is kept the same. If, however, the gas is prevented from expanding, the more rapidly moving molecules collide with the walls of the container with greater impact and the pressure of the gas is increased.

If a gas is cooled, the motion of its molecules becomes slow and they travel less distances before colliding with each other. Therefore the volume of the gas decreases on cooling provided its pressure is kept constant. If the volume of the gas is kept constant its pressure decreases.

Change of State on heating

You know that ice melts on heating i.e., when ice is heated, it changes from solid to liquid state. While the ice is melting, the temperature of mixture of ice and water does not increase although it is being heated all the while. The heat required to change the state from solid to liquid is called the *latent heat of fusion.*

When water is heated, its temperature starts rising till it begins to boil at 100°C. In other words water changes from liquid to gaseous state. While boiling the temperature of water does not rise beyond 100°C although it is getting heat continuously. Heat required to change water from liquid to gaseous state is known as *latent heat of vaporisa-*

tion of water. In the same way when other substances such as iron, wax etc., change from solid to liquid state or from liquid to gaseous state, latent heat is required, but during the change of state the temperature of the substance remains constant. Now we shall explain the change of state of a substance on kinetic theory of heat.

We know that when any solid is heated, its molecules start vibrating rapidly and its temperature rises. With continued application of heat to a solid, the vibrations of the molecules become so violent that intermolecular forces become much less effective to hold the molecules together and the molecules start moving or rolling freely over one another. This is the process of melting. During this process the applied heat is used up entirely in overcoming the intermolecular forces and there is no increase in energy of motion of molecules at this stage. Therefore, temperature does not rise while melting is going on.

Similarly when a liquid is heated, its molecules start moving rapidly and its temperature rises. If the liquid is heated continuously, the motion of its molecules becomes so violent at a certain temperature that some of the molecules overcome the intermoleculer forces completely and shoot out of the liquid surface. These are now free to move about in space. This is the process of boiling. During this process the applied heat is used up in tearing apart the molecules from the liquid. There is no increase in the energy of motion. Therefore there is no increase in the temperature of the liquid while boiling is going on.

5.4 Transmission of Heat

We, daily, observe at many occasions that heat flows from a hot to a cold body. For example heat from a fire-place passes into a kettle and is used to cook food in it. Some heat from the fire-place spreads into the kitchen and makes it hot. Heat is transmitted from one place to another by three modes and these are known as *conduction*, *convection* and *radiation* of heat. We will now discuss these modes of transmission of heat in detail.

5.5 Conduction of heat

If a metallic spoon remains for some time in the boiling water in a kettle the handle of the spoon becomes pretty hot. In this case heat from the hot water has been transmitted through the spoon and has reached its handle. This mode of transmission of heat is called *conduction of heat*. We shall now explain conduction of heat by the following experiment.

Experiment

Take two similar rods of equal length, one of copper and other of glass. Attach wax balls to these rods at equal distances and heat one end of each rod in the flame of a burner as shown in Fig. 5.2. You will observe that after

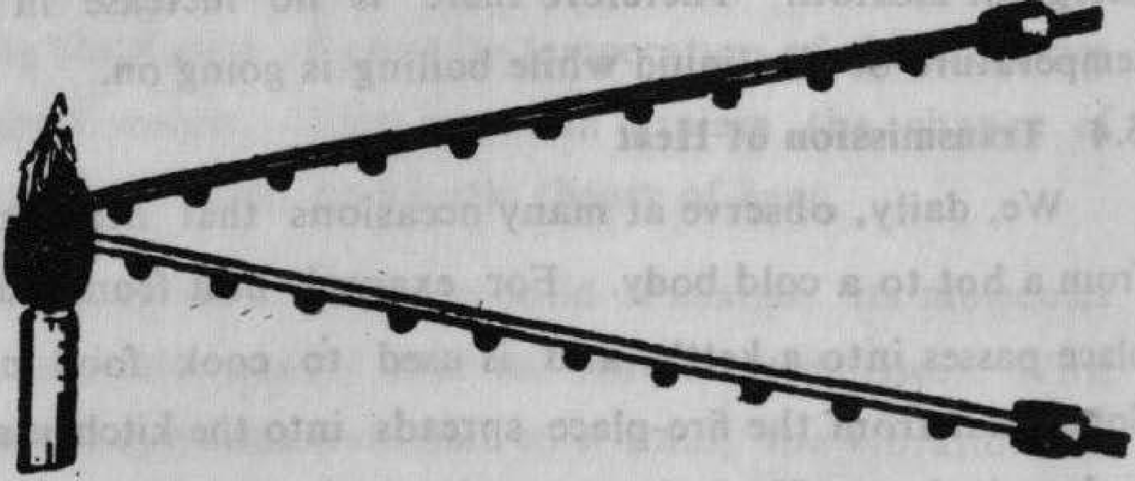


Fig. 5.2

some time the wax balls start falling from near the ends of rods placed in the flame. After a sufficient time you will observe that the distance from the hot end upto which the wax balls have fallen, is more in the case of copper rod than that in the case of glass rod. You will also see by moving the finger over the rods that the temperature of these rods continuously increases from cold to hot ends. You know that wax balls fall because of melting of wax which requires the absorption of heat. We can draw the following two conclusions from this experiment.

(i) Heat is conducted through an object from its hot to cold end.

(ii) Different objects differ widely in their ability to conduct heat.

Objects which conduct heat easily are called *good conductors* of heat such as metals particularly silver, copper, aluminium etc. On the other hand objects which do not conduct heat so easily are called *bad conductors* or *insulators* of heat. Glass, wood, cork, plastic etc., are examples of insulators of heat.

Conductors as well as insulators of heat are helpful to us in our daily life. See Fig. 5.3 and tell where and how conductors and insulators are useful to us.

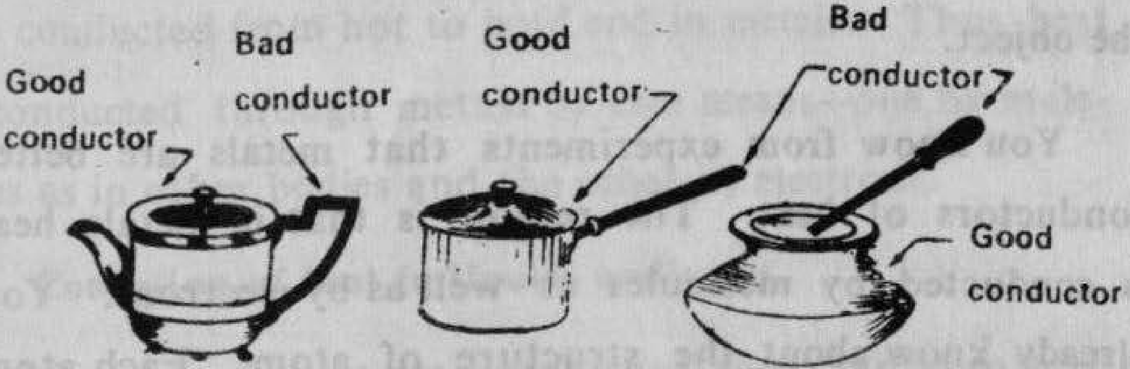


Fig. 5.3

Metals are good conductors of heat. Therefore utensils used for cooking are made of metals such as iron, copper or aluminium, but their handles are made of insulating material such as wood or plastic.

Now we shall try to explain conduction of heat on the basis of kinetic theory of heat. You know that all substances are made of molecules and these molecules are either vibrating at their own places or moving from one place to another. When one end of an object is heated. the motion of the molecules of this end becomes more rapid. These rapidly moving molecules collide with their neighbouring molecules and hand over some of their kinetic energy—heat energy-to them. As a result the motion of the neighbouring molecules increases. These molecules in turn collide and transfer some of their energy to the next molecules. This process continues till heat energy reaches the other end of the object.

You know from experiments that metals are better conductors of heat. The reason is that in metals heat is conducted by molecules as well as by electrons. You already know about the structure of atom. Each atom has a nucleus at its centre which carries a positive charge. Electrons which carry negative charge revolve around the nucleus in different orbits. As the nucleus and the electrons revolving around it carry opposite charges, there exists a force of attraction between them. This force of attraction keeps the electrons in their orbits. The above mentioned description is about the structure of an isolated atom. In case of metals the atoms are situated so close to one another that the nucleus of one atom can affect the electrons in the outer most orbits of the neighbouring atoms. Therefore the electrons in the outer most orbits of atoms can move from one atom to the other inside the metal. These electrons are called *free* or *conduction electrons*. The electric current through metallic wires is due to the free electrons. When one end of a metallic rod is heated, the kinetic energy of the electrons in this end increases. These fast moving electrons collide with the neighbouring atoms and transfer their extra energy to them. By this means heat energy is also conducted from hot to cold end in metals. Thus heat is conducted through metals by two means—one by molecules as in other bodies and the other by electrons.

5.6 Condution of heat in liquids and gases.

Liquids and gases are usually not good conductors of heat. This fact can be verified by the following experiments.

Experiments.

Put a piece of ice in a test tube and drop a piece of stone so that the piece of ice is pressed down. Now pour water in the test tube. The piece of ice will not be able to float because of the pressure of the stone. Heat the test tube near the water surface as shown in Fig. 5.4. After sometime water near the surface will start boilling while the piece of ice at the bottom will not melt much. It is quite clear from this experiment that water is a poor conductor of heat. Like water many other liquids are also poor conductors of heat.

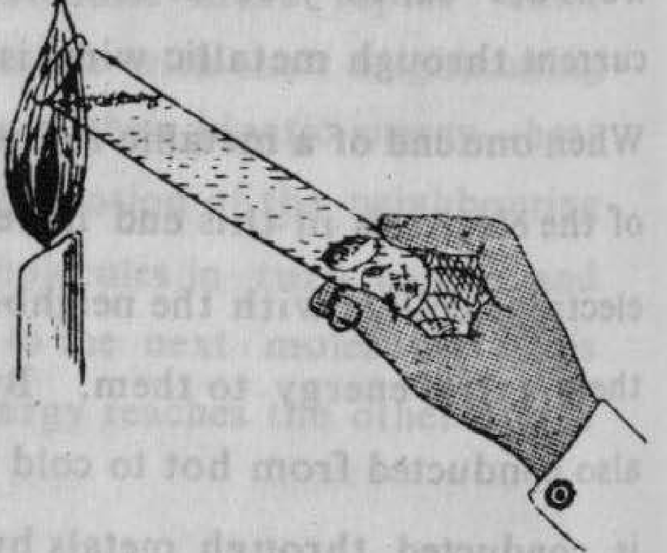


Fig. 5.4.

Gases are better insulators of heat as compared to liquids. Gases, as bad conductors are used in many ways. A few examples are given below.

You might have observed that some animals or birds fluff their hair or feathers as a precaution against cold. By doing so a layer of air is trapped in between their hair or feathers. As air is a bad conductor of heat, the layer of air prevents the heat of their bodies from escaping.

In winter we wear woollen clothes because there is a layer of air between their fibres which does not allow the heat of our bodies to escape and this is the reason why woollen clothes feel warm. The quilts also have the same function.

In the windows of air-conditioned rooms double glass sheets held parallel to each other at some distance, are used

The layer of air between two glass sheets does not allow heat to come into the room from outside during summer, but during winter it does not allow the heat produced inside the room to escape. Sometimes the walls of these rooms are also made double. The layer of air enclosed in between such double walls does not allow heat to come from outside into the room or to escape from the room.

The building materials which are used as insulators have many pores in them. The air enclosed in these pores makes them good insulators of heat. Cork, cement etc., are few of the examples.

Convection of heat.

We shall now consider a second mode of transmission of heat which is known as *convection* of heat and it is only possible in liquids and gasses. We shall consider few examples to understand this mode of transmission of heat fully.

Experiment.

Take a beaker half full of cold water and float a wooden block on the surface of water. Slowly pour hot

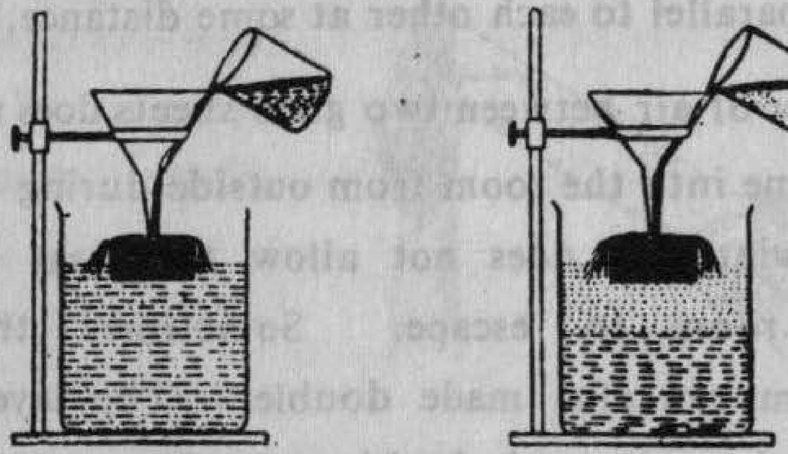


Fig. 5.5.

coloured water on the wooden block by means of a funnel. You will see that cold clear water and coloured hot water remain separate for some time.

Now repeat this experiment by taking hot coloured water in the beaker and then pouring clear cold water on it by using a wooden block and a funnel as before. This time coloured water and clear water will mix very soon.

We can conclude from this cxperiment that hot water is lighter than cold water. It is due to this reason that in the first part of the experiment the coloured water which was lighter than cold water remained separate for quite a long time. In the second part of this experiment the coloured water being lighter, came upward and the cold water being heavier went down and so they mixed with each other earlier.

Like water all other liquids and gases become lighter and rise up on being heated. On the other hand they become heavier and sink down on cooling. Such movements of liquids and gases help in the transmission of heat which is explained by the following experiments.

Experiment.

Take a big beaker nearly full of water and hold a glass tube vertically on one side of its bottom. Drop few crystals of potassium permanganate down the tube. These crystals will collect on the bottom and will leave a coloured trail in the tube, Now close the upper end of the glass tube with a finger and lift the tube slowly. The coloured water will come out alongwith the tube. See that water round the crystals is not disturbed.

Now heat the beaker by placing a spirit lamp under neath the crystals. The water around the crystals becomes warm, it becomes lighter and rises up. You will see a coloured trail rising up. Cold water comes down to take

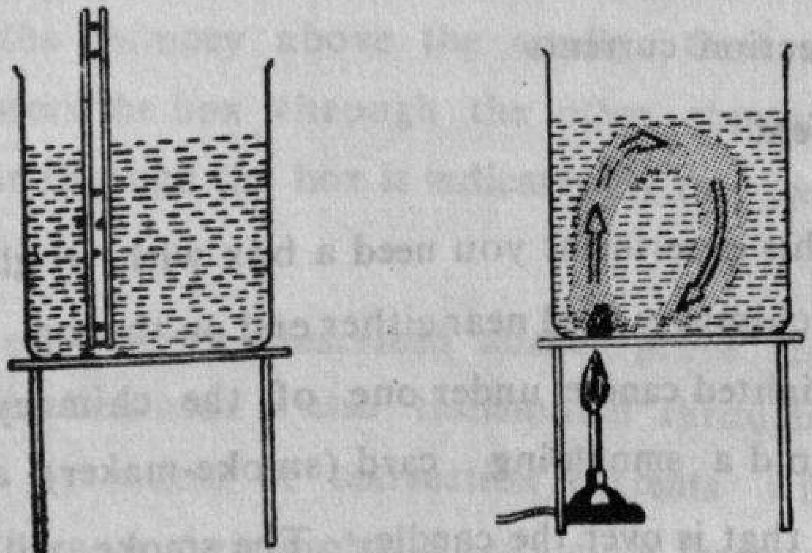


Fig. 5.6

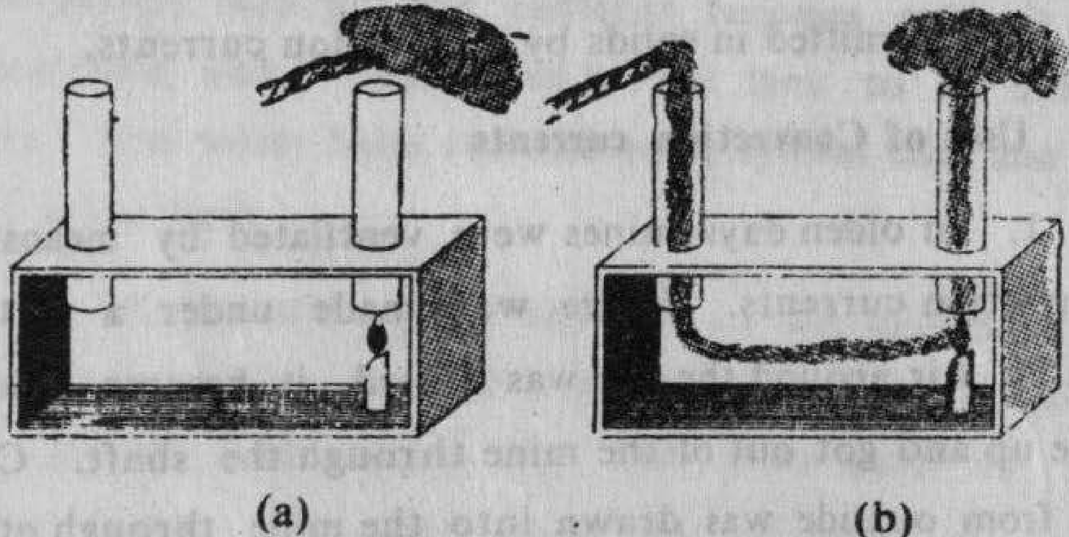
the place of warm water which has risen up. In this way a current is set up in the water in the beaker, This current is known as a *convection current*.

With the setting up of convection current water above the flame absorbs heat, it becomes warm and lighter and rises up. Surrounding cold water takes its place, absorbs heat and also rises up. The process is continued and the heat of the flame is transmitted to the whole of the volume of water which is heated uniformly. Such a mode of transmission of heat is known as *convection of heat*. In all liquids heat is mostly transmitted by convection as in the case of water.

Now we shall prove that heat is transmitted in gases by convection currents.

Experiment

In this experiment you need a box with a glass front and two chimneys fixed near either end on the top (Fig. 5.7) Place a lighted candle under one of the chimneys in the box. Hold a smoulding card (smoke-maker) above the chimney that is over the candle. The smoke will be seen to rise as shown in Fig. 5.7 (a). Now hold the smoke



(a) (b)

Fig. 5.7

maker over the other chimney. The smoke will be seen to enter box through this chimney and leave through the other chimney (Fig. 5.7 b). In the second case the smoke takes, this path because the air over the flame of the candle becomes warm and lighter and goes out of the box through the chimney above the candle. Cool air from outside enters the box through the other chimney. The path of air through the box is indicated by the passage of smoke.

The experiments described above prove that apart from conduction heat is also transmitted through liquids and gases by means of convection currents which are produced because their molecules can move from one place to another. As the molecules of solid cannot move freely, so convection currents cannot be produced and heat can not be transmitted in solids by convection currents.

5.8 Uses of Convection currents

1. In olden days mines were ventilated by means of convection currents. A fire was made under a vertical shaft. Air around the fire was heated, it became lighter, rose up and got out of the mine through the shaft. Cold air from outside was drawn into the mine through other shafts. Nowadays large electric fans are used for this purpose. These fans, fixed at the inner end of the shaft, push out air from the mines. The currents of air produced by fans or blowers are called *forced convection currents.*

2. Ventilators are built at a little height in the rooms. Air inside becomes warm by fire or by the respiration of occupants, it becomes lighter, rises up and goes out from the ventilators. Cool fresh air from outside is drawn inside the room through doors and windows.

3. Use of convection currents in the household hot water system is quite important. Water is heated in a tank by the burning of gas or oil. Water, on being heated becomes lighter, it rises up and circulates in zig-zag pipes, called radiators fixed inside the room. The radiators transfer the heat of hot water to air inside the room. Water

after passing through the radiator becomes cold, it becomes heavy and is transferred to the tank to be heated again. Hot water from the hot water system can also be used in the bath.

4. Climate of a region depends on the movement of air currents to a great extent. Near sea shores wind blows from sea to land during day and from land to sea during night. For this reason the climate of these regions remains moderate. Wind blowing from sea to land during the day is called *sea breeze* and that blowing from land to sea during night is known as *land breeze*. Let us find out the cause of this daily change in the direction of the wind. During day heat from the sun raises the temperature of land more quickly than that of the sea water. The air over the land is heated faster, it becomes lighter and rises up. The cold air over the sea replaces the warm air, thus producing sea breeze.

During night the process is reversed. The land areas cool off faster than the sea water. Therefore air over the sea is warmer than that over the land. The warm air over the sea rises up and is replaced by cold air over the land, thus producing land breeze.

Sea and land breezes are local winds and they can only affect the climate of the regions near the sea shore. The windows and ventilators of houses in the cities near the shore are so located that the wind can enter the houses during day and night.

Winds blow on a much larger scale on the surface of earth. They are also due to difference of temperature between two regions. Monsoons, trade winds etc., are some of them about whom you will study in detail in geography books.

5.9 Radiation of Heat;

Sun is the biggest source of heat for us. Our earth receives major portion of heat energy from the sun. Let us see how heat of the sun reaches us. We know that our atmosphere extends at the most uptil 1609 kilometers above the surface of the earth. After that there is no air at all i.e., there is vacuum uptil the sun. The heat of the sun reaches us even in the absence of any material medium between the sun and the earth. The heat from the sun, therefore, cannot reach the earth by conduction or convection because both these modes of transmission of heat require material medium. The third way by which heat travels across vacuum is called *radiation* and the heat energy so transferred is called *radiant energy*. Heat energy is transmitted from a hot body to a cold one without the help of any material medium by means of radiation. Now we shall discuss the various properties of radiant energy.

(i) Radiant energy travels with the velocity of light.

When a cloud comes before the sun, the heat and light from the sun are cut off simultaneously. It shows that both light and radiant energy travel with the same speed which is equal to 3×10^5 kilometers per second.

(ii) Radiant energy can be reflected.

Radiant energy can be reflected in the same way as light. The reflection of radiant energy can be studied by the following experiment.

Let one of your friends hold a mirror in the sun so that the image of the sun is thrown on you. You will feel warm. This shows that radiant energy can be reflected by a mirror just as light is reflected. If your friend uses a card board piece in place of mirror, you will not feel warm. We can draw the following conclusions from this experiment.

(i) Radiant energy can be reflected in the same way as light.

(ii) Shining surfaces are better reflectors of radiant energy as compared to dark coloured surfaces.

(iii) Radiant energy can be refracted.

Radiant energy can be refracted just like light rays i.e., while passing from one medium to another medium radiant energy deviates from its original direction. We can show the refraction of radiant energy by using a convex lens. Radiant energy from the sun after passing through a convex lens deviates from its direction and is focussed at a point. If a piece of cloth or cotton is placed at that point, it catches fire.

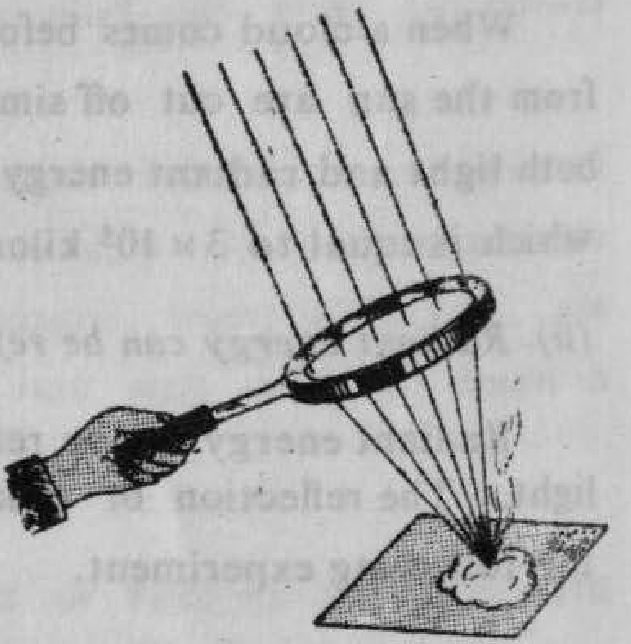


Fig. 5.8

(iv) Radiant energy can be absorbed.

Radiant energy can be affected by a surface which it strikes in three ways. (i) It can be reflected. (ii) It can pass through a medium and while doing so it can be refracted. (iii) It can be absorbed by a medium.

Usually when radiant energy strikes a body, a part of it is reflected, another part passes through it and the remaining portion is absorbed in the body. When radiant energy strikes a transparent material such as air, water, glass etc., a major portion of it passes through and a small portion is reflected or absorbed. When radiant energy is falling on a shining surface e.g., mirror, a large part of it is reflected and a small part is absorbed. If radiant energy falls on a dark coloured or black surface, its major portion is absorbed and very little portion is reflected.

Now we will prove by an experiment that dark coloured surfaces are better absorbers of radiant energy as compared to shining surfaces.

Experiment

Suspend two similar thermometers side by side in the sun. Both of them will show the same temperature. Now wrap a white cloth around the bulb of one thermometer and a black cloth around the bulb of the other. After some time the thermometer with a black cloth will indicate a higher temperature. This' experiment proves that black or dark coloured objects absorb more radiant energy than the white or light coloured objects.

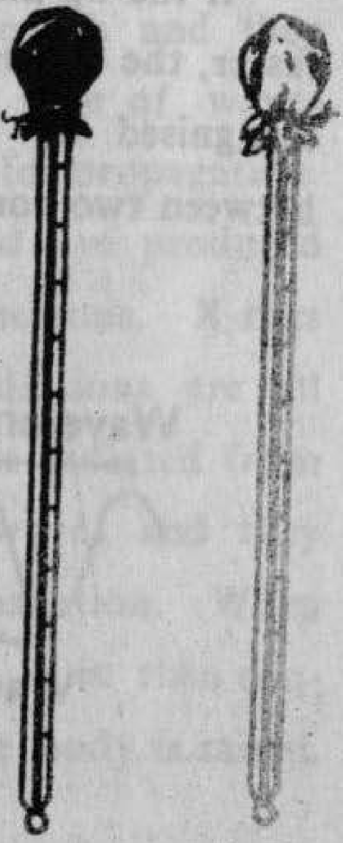


Fig. 5.9

Because of this property of black cloth people wear dark coloured clothes in winter and light coloured clothes in summer.

Now we will explain in detail the propagation of radiant energy. Consider the following experiment.

Take a large tub of water. Dip one end of a vertical stick in water near one edge of the tub. Move the stick up and down quickly. Waves will be produced on the surface of water and they appear to move outward. The waves are composed of crests and troughs. Every crest is followed by a trough and every trough by a crest.

If the up and down motion of the stick is made a little faster, the waves will close up. The different waves are recognised by their wavelength which is the distance between two consecutive crests or troughs.

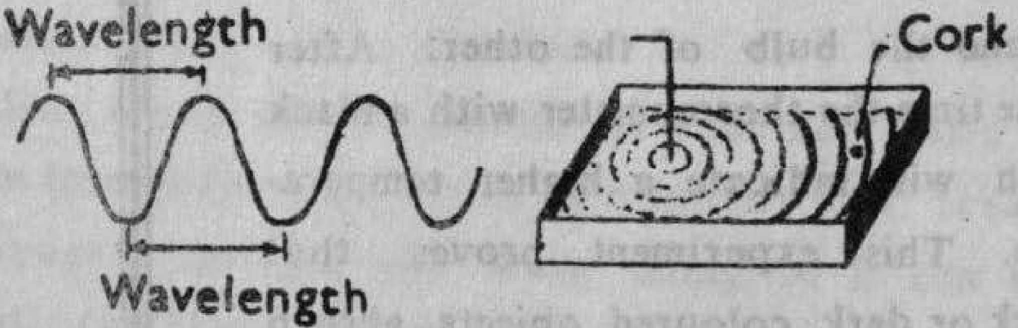


Fig. 5.10

Now float a piece of cork on the water near the opposite edge of the tub. We will see that cork vibrates up and down at its place when the waves pass over it. We know that energy is needed for producing motion in the cork. The question arise : How cork gets this energy? We have spent energy in moving the stick. This energy has been carried by waves to the cork and so it is set into vibrations. This experiment indicates that energy can be carried by waves from one place to another.

We have seen that waves are produced by the vibrations of some object on the surface of water. Similarly waves can be produced in any medium by the vibration of some objects. These waves differ in wavelength and they travel in some medium. There is another type of waves which do not require any material medium for propagation. These are called *electromagnetic waves* and are produced by the vibrations of molecules, atoms or electrons. X-rays light rays, radio waves and also heat radiations are all examples of electromagnetic waves. Heat is radiated from hot bodies in the form of electromagnetic waves and they do not require any medium for their propagation. When heat radiation falls on any material body, it is then converted into heat and the temperature of the body is raised.

Questions

1. Explain the difference between quantity of heat and temperature on basis of kinetic theory of heat.

2. Which one of the following articles possesses more quantity of heat and which is at a higher temperature and why ?
   (i) red hot needle
   (ii) a bucket full of warm water.

3' Explain the following thermal effects on the basis of kinetic theory of heat.
   (i) Thermal expansion
   (ii) Change of state by heating.

4. Why does the temperature of boiling water remain steady even though it is being heated continuously.

5. Explain the similarities and differences between conduction and convection of heat—

How is radiation of heat different from conduction and convection ?

6. Why do we use quilts for protecting ourselves from cold. Does a quilt produce heat.

7. A paper wrapped around an iron bar does not catch fire when heated.

8. The temperature of a hot or cold liquid can be maintained for a long time when kept in thermos flask. Explain how heat is prevented from going in or out of the flask keeping in view the three modes of transmission of heat.

9. In old times a special type of lamp was used in mines where there was some combustible gas. This was named as Davy's safety lamp. It is an ordinary lamp with a metallic wire gauze casing around it. Explain its working.

10. What are the advantages of having ventilators in the rooms.

11. Flame always rises up. Why ?

12. Why does dirty ice melt earlier ?

13. Usually people in hot countries wear white clothes but those living in cold countries use dark coloured clothes. Why ?

14. Full up the blanks.

(i) Heat is a form of ——.

(ii) Quantity of heat in a body is the——of the kinetic energies of its molecules.

(iii) The temperature of a body depends on the——kinetic energy of its molecules.

(iv) Bodies——on heating.

(v) While melting the heat given to a solid is used up in overcoming——forces.

(vi) In conduction heat energy is transferred by rapidly

——molecules hitting the neighbouring molecules vibrating with less energy whereas in convection heat energy is transmitted by molecules moving from one to another place.

(vii) ——is transferred from a hot body to a cold one by radiation.

(viii) Shining surfaces——more heat as compared to light coloured surfaces.

* * *

6

Climate and Weather

It is a common experience that sometimes it is warm while at other times it is cold. At times it rains while at other times it is dry. A place is extremely cold while other places are warm. At any place the general condition due to temperature, rains etc., is called *climate* of that place. For example, the climate of Murree is cold, that of Lahore Multan and Bahawalpur is warm and dry while climate of Karachi is moderate and moist.

The daily changes in climate are called the *weather*. You might have listened to the daily weather forecasts on radio informing about the dry weather or rainy weather etc., during the next twenty-four hours. The weather-forecast is made on the basis of the observations of the atmosphere. In this chapter, we shall study those changes of atmosphere which affect the weather.

6.1 Evaporation and condensation

Nearly 99% of the atmospheric air consists of oxygen and nitrogen. The remaining part is composed of carbon dioxide, dust particles, organic matter, rare gases and water vapours, The weather changes are mainly due to water vapours present in the air. How do water vapours come in the air? We perform an experiment to study the presence of water vapours in air. Take few drops of water in a dish and place it in an open place. After sometime the water will evaporate and the dish will be dry. This change of water into water vapours is known as *evaporation*. The process of evaporation always takes place at the surface of water. The water keeps evaporating into the air from the surfaces of lakes, oceans, rivers and canals etc.

Explanation of Evaporation: Water consists of molecules. These molecules are in constant motion. All the molecules do not move with the same speed. Some move faster than the other. On reaching the surface some of the fast moving molecules sometimes leave the surface of water and escape into air in the form of water-vapours. This is the reason why evaporation always takes place at the surface of the liquid.

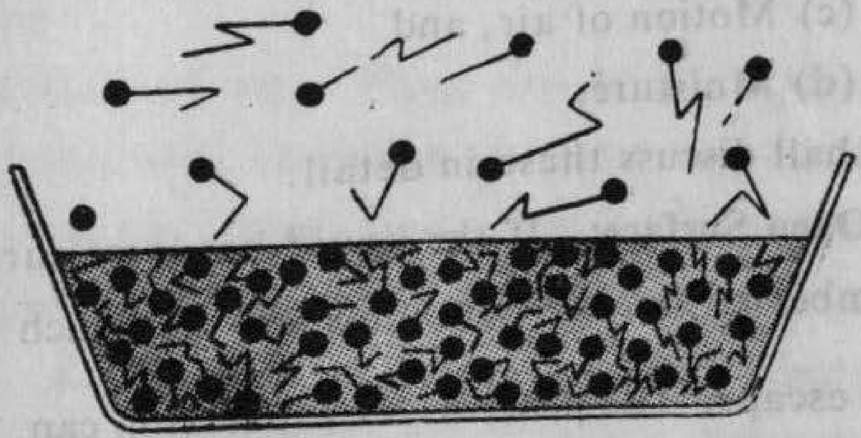


Fig. 6. 1

Condensation: When a certain mass of air is cooled, the water vapours present in it again change into water drops. This process is called *condensation.*

Experiment: Take some water in a tumbler. Add some pieces of ice to the water. Wipe the outer surface of tumbler and place it in an open space. After sometime tiny droplets of water will appear on the outer surface of the tumbler. These droplets are formed due to condensation of the water vapours present in the air. When air touches the outer surface of the tumbler, it gets cooled and speed of the molecules of the water vapours present in it are slowed down. These are thus changed into water droplets and stick to the surface of the tumbler.

6.2 Factors affecting the rate of evaporation:

The following factors affect the rate of evaporation:

(a) Area of liquid surface,
(b) Temperature,
(c) Motion of air, and
(d) Moisture.

We shall discuss these in detail.

(a) Open Surface: If the liquid has large surface area, large number of fast moving molecules can reach the surface and escape, The process of evaporation can, therefore, take place rapidly, Thus evaporation takes place from the surface of ponds, lakes, oceans etc, at all times. One of the reasons for keeping the liquids in bottles is to keep their open surface small thus reducing their loss due to evaporation.

Experiment: Take few drops (say 10) of water in a test tube and an equal amount in a flat dish, and place both before an open window. After some time the water in the dish will evaporate completely while some water still remains in the test tube. This experiment proves that the evaporation depends on its open surface.

(b) Temperature: Take two identical handkerchiefs and make them wet. Spread one handkerchief in sun and the other in shade. The one lying in sun dries first.

The temperature of the handkerchief lying in the sun rises. At the higher temperature the kinetic energy of the molecules also rises. Therefore, they easily escape into air and so the water evaporates and the handkerchief dries earlier.

(c) Motion of air: Place one of the handkerchief of the above experiment in the room under the fan and the other in calm air. One lying under the fan will dry first. Thus evaporation is accelerated in fast moving air. When air is not moving, the part of it near the surface of water becomes saturated with water vapours and cannot hold more vapours. While in a fast moving air the part that becomes laden with water vapours moves onward and fresh air comes in its place to receive more vapours. Thus the process of evaporation continues.

(d) Moisture: The amount of moisture present in the air also affects the rate of evaporation. If the air is dry, it can hold more water vapours and the process of evaporation is speeded up. If the air is already moist, it can further take up only small amount of vapours thus the process of evaporation is slowed down. This is the reason why wet clothes take longer time to dry in the rainy season.

6.3 Effects of evaporation on Living Things

Due to evaporation the fast-moving molecules escape from the main body of water. The remaining water is thus cooled. After taking a bath, water evaporates from our bodies and we feel cool. In the earthen pot (Matka) the water oozes out of the pores and evaporates at the outer surface. This cools the water in the "*matka.*"

During hot weather we perspire. The sweat evaporates and we feel cool.

There are certain animals which do not perspire. Thus during summer the dog breathes heavily with his tongue stretched out. Evaporation takes place from the tongue and the body of dog is cooled.

Water evaporates from the leaves of plants. The water from the soil enters the roots, passes through the stem and the branches and evaporates from the leaves. In this way an average plant loses water equal to several hundred times its own weight during one season. That is why the forests and gardens are cooler during the summer season.

6.4 Weather

(a) **Humidity :** When the amount of water vapours present in air increases, we say that the air is more humid. On the other hand when the amount of water vapours in the air decreases, the air becomes dry. The amount of water vapours in the air determines the *humidity* of air.

When moisture in the air increases to the extent that it cannot absorb more water vapours, the air is said to be saturated with water vapours. If saturated air is heated, it can hold more water vapours. Thus the humidity depends upon the amount of water vapours present in the air and on its temperature. The instruments used to measure the humidity of air is called *hygrometer*. Besides other factors, rainfall also depends upon the humidity of air. Thus when humidity increases, there is a greater likelihood of rainfall.

(b) **Snow, Dew, Frost, Mist and Fog :** When moist air gets heated, it expands and rises up. Cold and heavy air rushes down to take its place. The hot air on reaching higher altitudes, expands and cools down. Thus for rise of every 333 meters the temperature of air falls by about 5½°F. Moist warm air contains more water vapours. When it cools at higher altitudes, the vapours condense into water droplets. These droplets become heavier and air is unable to hold them. Thus they fall in the form of rain, hail, snow or fog etc. The difference in these depends upon the process of condensation. We shall now discuss these phenomena separately :

(i) **Snow** : When the temperature of clouds falls below the freezing point of water, the water vapours directly condense into crystals of snow. These crystals combine together to form snow-flakes.

(ii) **Dew** : After clear and calm nights, we observe drops of dew condensed on the leaves of grass etc. Dew is formed by the condensation of water vapours present in the air. During day time, air is warmed by the sun rays and water vapours combine with it. At night, the earth is cooled down and the air near its surface is also cooled. The water vapours present in air are condensed into water droplets and appear on the leaves of plants. Dew appears on the leaves because they evaporate water and the air surrounding the leaves contains more vapours which readily condense to form dew.

Frost : When the earth cools below the freezing point during night, the water-vapours present near it freeze into ice and appear as *frost*. Thus frost is not frozen dew but is formed due to direct freezing of water vapours into ice which appears on the earth surface etc. after intense cold nights.

Mist : During winter season you might have often observed the condensation of water vapours in air exhaled from your mouth. The water vapours present in the warm breath condense into water droplets when they meet the outer cold air. During winter season in the morning and evening the temperature drops and the water vapours present in the air start condensing on the dust and smoke particles. These water droplets suspended in air give rise to mist. Mist is seen over the cities and the factories during the winter season.

Deep mist with visibility limited to within 1000 meters is called *Fog.*

Besides cities, mist is also formed over valleys and seas. This is due to the mixing of cold air current with masses of warm moist air thus converting water vapours into droplets of water.

6.5 Weather Forecast

The changes in weather depend upon humidity, temperature, wind speed and air pressure. In order to forecast weather we need complete information about air conditions over vast areas besides local observations. The meteorologists make weather forecasts after determining general condition of air by measuring these conditions of air at different places. They use various instruments for this purpose.

The temperature affects the weather to a great extent. Therefore the meteorologists not only measure the maximum and minimum temperatures duriug the 24 hours but also record the temperature changes regularly by means of thermographs. Usually sudden temperature changes are accompanied by change in weather.

In order to measure humidity, we use *hgrometers*. One kind of hygrometer consits of two thermometers. The bulb of one of the thermometers is wrapped with a piece of muslin cloth whose lower end dips in a cup of water (Fig. 6.3). Due to evaporation of water, the wet-bulb thermometer shows slightly lower temperature. The humiditly of air is determined from tables by means of difference of temperature shown by the two thermometers.

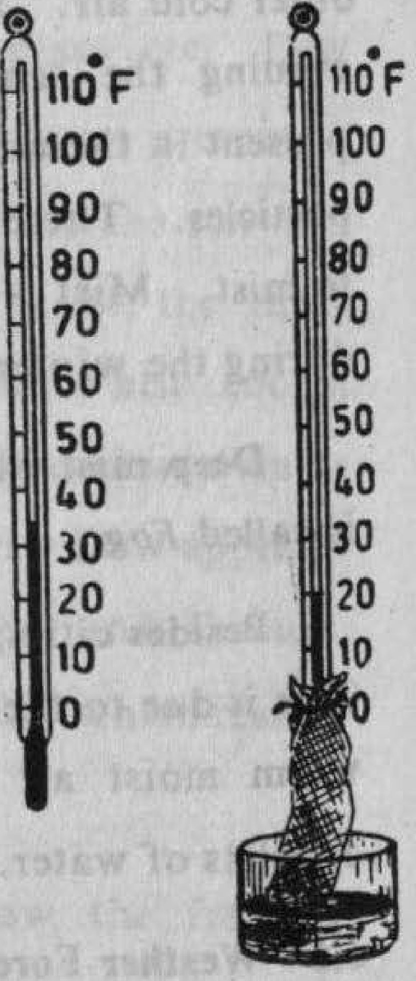


Fig. 6.3
Dry and wet bulb
hygrometer.

Barometer :—A barometer is used to determine the air pressure. After measuring the pressure over vast areas charts are prepared. The points of equal pressure are joined together on these charts. From the shape of these lines of equal pressure the tendencies of pressure changes are studied and changes of weather are forecast.

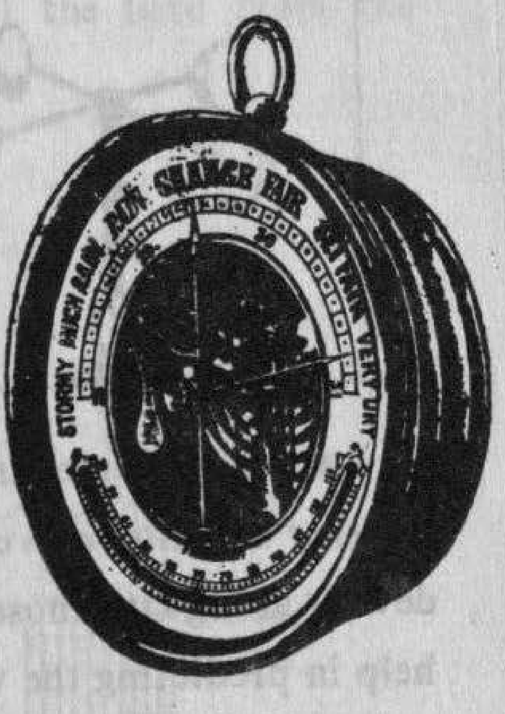


Fig. 6.4
Aneroid barometer.

You have already read about the mercury barometer is class VII. Dial type barometers are also in common use. These do not require mercury for their working. One such barometer, called *Aneroid barometer* is shown in Fig. 6.4.

In order to measure the speed and direction of flow of air, we use **Anemometer**. (Fig.6.5).

The observations of the changes taking place in air near the surface of earth are not sufficient to forecast weather. It is necessary to measure the temperature, humidity, pressure, wind direction and speed at higher altitudes as well. For this purpose baloons, rockets and weather satellites are used. Observations taken by these devices alongwith those taken at different ground stations help in predicting the weather changes.

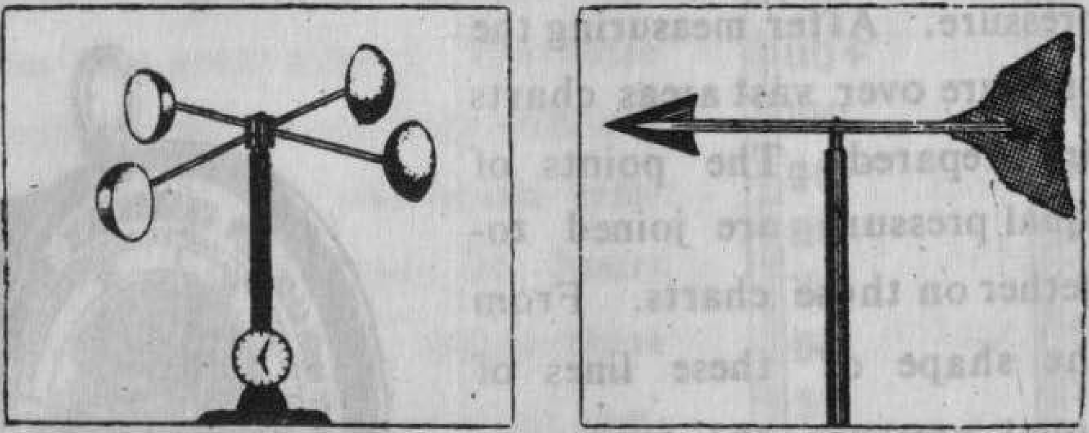


Fig. 6.5

Anemometer measures the speed and direction of air.

In the baloons, hydrogen or helium gas is used. A box containing instruments to measure air pressure, humidity and temperature is flown with the baloon. Observations of the floating baloon by means of telescope help in determining the speed of the wind. At high altitudes when the baloon bursts, the instruments fall on the ground safely by means of a parachute. A baloon can rise to about 24 to 40 kilometers.

In order to make observations of the atmosphere at higher altitudes, rockets are used. In addition to rocket, weather-satellites also send photos and other observations of the atmosphere. These are useful in better forecast of the weather.

6.6 The Water Cycle

The water keeps evaporating all the time from the surface of earth. During day time the rate of evaporation is faster because of the heat of sun and during night it is slower. The evaporation takes place from the surface of ponds, rivers, lakes and oceans etc. Water also evaporates from the leaves of plants. During a day a plant may lose water in the form of vapours upto an amount equal

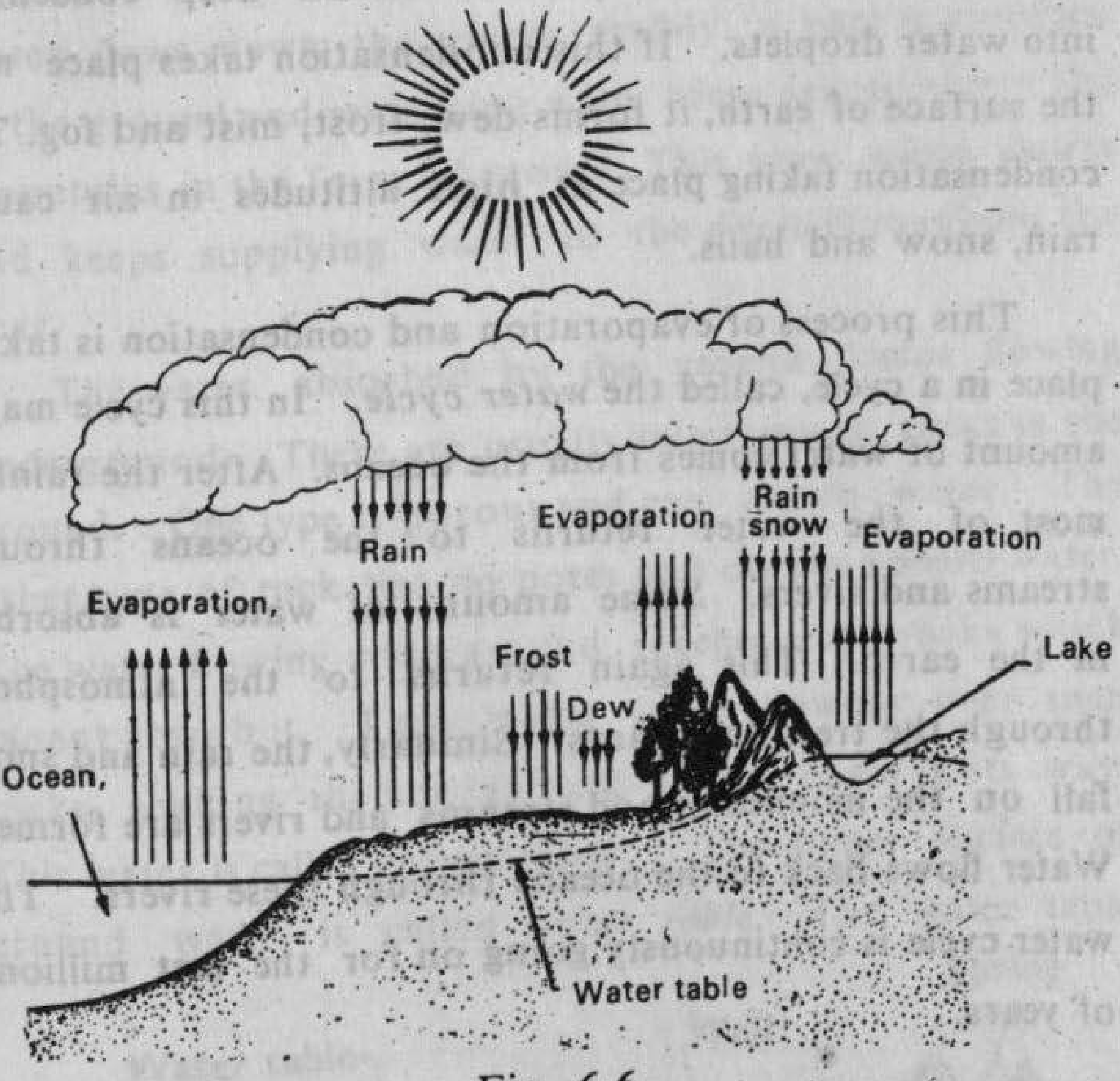

Rain
Evaporation
Rain
snow
Evaporation
Evaporation,
Frost
Lake
Dew
Ocean,
Water table

Fig. 6.6

to its own mass.

The water vapours present in air keep condensing into water droplets. If this condensation takes place near the surface of earth, it forms dew, frost, mist and fog. The condensation taking place at high altitudes in air causes rain, snow and hails.

This process of evaporation and condensation is taking place in a cycle, called the *water cycle.* In this cycle major amount of water comes from the oceans. After the rainfall most of the water returns to the oceans through streams and rivers. Some amount of water is absorbed in the earth. This again returns to the atmosphere through the trees and plants. Similarly, the rain and snow fall on the mountains and streams and rivers are formed. Water flows back to the oceans through these rivers. This water cycle is continuously going on for the last millions of years.

6.7 Ground Water

You might have observed water running in streets and roads during the rainfall. This water flows through the drains and shortly after the rain is over, these little streams stop flowing, The remaining water evaporates into air. But the rivers keep flowing throughout the year. Where from the water of a river comes? Water falls over the mountains in the form of rain and snow. A part of this water flows down the rivers readily, a part is absorbed in the ground and remaining water keeps deposited over the mountains in the form of snow. This snow melts slowly and keeps supplying water to the rivers throughout the year.

The water, absorbed by the ground, keeps flowing underground. There are usually two types of rocks in the ground. One type is porous and can absorb water. The other type of rock has no pores and cannot absorb water. The water flowing underground reaches such rocks which cannot absorb it. Then water starts flowing over such rocks, soaking the porous rocks as they come in its way. This water is called *ground water*. The upper surface of ground water is called *water table*. The water table

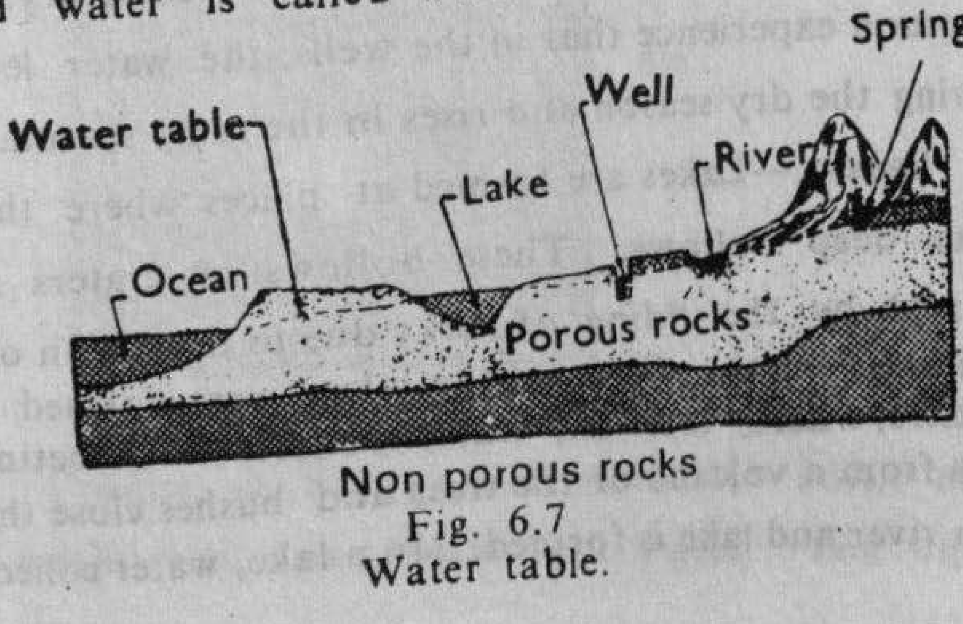


Fig. 6.7
Water table.

is at different depths below the earth's surface at different places. At a particular place, the water table rises during rainy season because the rain water is absorbed in the ground and adds to the ground water. During the dry season, the water table is lowered.

The water-table slopes down or upward as we move along the surface of earth. In hilly areas, wherever the surface of earth is below the water-table, the ground water comes out in the form of a spring. The spring-water has dissolved minerals in it.

Wells :—We always dig wells deep enough so that it is below the water table. The water present in the nearby rocks collects in the well. When we take out water from the well, the water flowing underground again fills it. The well should always be so deep that during the dry season when water table falls, it should not become dry. It is a common experience that in the wells: the water level falls during the dry season and rises in the rainy season.

Lakes :—Lakes are formed at places where there are some deep hollows. These hollows or craters may be formed by the sliding of rocks due to the action of forces inside the earth. Some of the lakes were formed by the glaciers, where, later on, water collected. Sometimes the lava from a volcano or the trees and bushes close the path of a river and lake is formed. In a lake, water collects from rain or from rivers. Ground water also collects in a lake which is deeper than the water table.

(a) The Water Pressure and Town Water Supply :— You have already studied that air exerts pressure due to its weight. Like air water also exerts pressure. If we immerse anything in water, then water above it exerts pressure due to its weight. Water exerts pressure in all directions and water pressure increases with depth.

Experiment :—

Fill a glass trough with water. Immerse a narrow mouthed and long necked bottle with its mouth downward

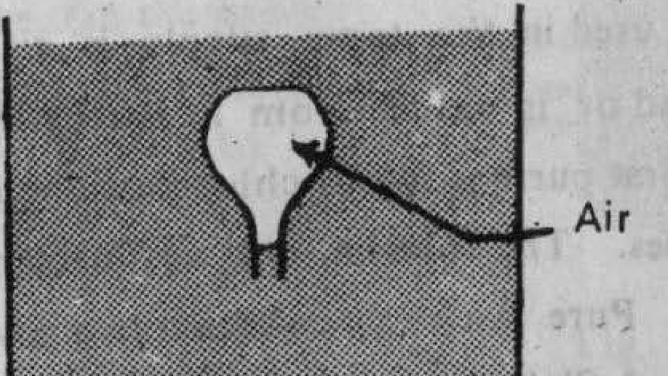


Fig. 6.8

Find the amount of water that enters the bottle at different depths below the surface of water. You will find that more water enters the bottle at greater depth. The bottle is filled with air. The air inside the bottle is under greater peessure at greater depth and is compressed more and more, therefore water enters the bottle. This experiment proves that with increasing depth below the surface of water, the pressure increases.

Water always flows from a higher place to a lower one Thus whenever water is flowing, it moves from a place of higher pressure to that of lower pressure. In towns the water can be supplied from a tank situated at a higher level through pipes to houses down below.

The water used in the town supply is either drawn from the ground or is taken from a nearby river. The river water is first purified and is chlorinated before supplying to the houses. The chlorine kills any bacteria present in the water. Pure water is collected in a covered tank.

6:9 Floating and Sinking

Whenever an object is placed in water, it experiences pressure. Because the water pressure increases with depth, therefore the pressure at the lower surface of the immersed object will be greater than that at the upper surface. Figure 6.9 shows a cylinder immersed in water. Pressure at the lower surface of this cylinder will be greater than the pressure at its upper surface. This difference of pressure exerts an upward thrust at the cylinder.

Besides the pressure of water, its weight pulls the cylinder downward. Thus the upward thrust of the water pushes the cylinder upward and its weight pulls it in the downward direction. If the weight of the cylinder is less than the upward thrust of water, the cylinder will come up and start floating on the water surface. On the other hand if the immersed object is heavy and its weight is greater than the upward thrust of water, the object will sink in water.

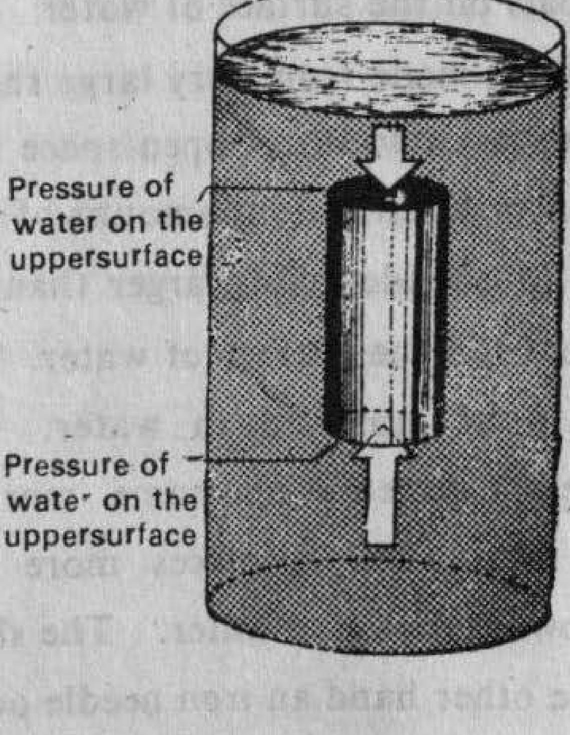


Fig. 6.9

The thrust experienced by an object immersed in water depends upon the amount of water displaced by the object. In other words the thrust depends upon the amount of water which will occupy the space filled by an immersed object. Usually small and heavy objects sink in water because they displace small quantity of water and so they experience small upward thrust.

Large and light objects usually float on the surface of water. These objects occupy large space and displace more quantity of water. They, therefore, experience greater thrust.

Iron is heavier than water but the ship made of iron floats on the surface of water. This is possible because the ship is made from very large sheets of iron and steel and has vast amount of open space in it. The ship thus displaces an enormous amount of water. The thrust of water is thus made much larger than the weight of ship and it floats on the surface of water. The lower part of a floating ship is immersed in water. When the ship is loaded, its weight increases and some more part of the ship immerses in water. This displaces more water thus increasing the upward thrust of water. The ship thus keeps floating. On the other hand an iron needle occupies very small space and displaces small amount of water. It experiences little upward thrust and so it sinks in water.

A submarine also floats like a ship. It contains several tanks. When these tanks are filled with water, the weight of the submarine becomes greater than the thrust of water. and it sinks below the surface of water. When it is required to come up, the water is pumped out of these tanks and the submarine becomes lighter, comes up and floats on the surface of water.

6.10 Hard Water and its Softening

As you know we get water through rains, oceans, rivers, wells, lakes, springs etc. Many types of impurities are present in water. Some of these impurities like mineral salts, gases etc., are soluble. A few of the impurities are insoluble in water. These are dust particles, sand, bacteria etc. When the bicarbonates of calcium and magnesium are dissolved in water, it is called *hard water*. Hard water cannot produce lather with soap. Instead precipitate is produced when soap is added. We shall prepare some hard water and perform some experiments with it.

Experiment :—

Take some lime water in a bottle. Blow through a drinking straw into the lime water. It will turn milky. Continue blowing till the milkiness disappears and the lime water again becomes clear. Add some pure water to it. You have prepared hard water.

Heat pure water and dissolve some soap in it. This makes a soap solution.

Take some tap-water in a test tube and add one spoonful of soap solution in it. Shake the tube. After some time lather will be formed on the water. If lather is not produced, add some more soap solution and produce lather

Clean the test-tube and take some hard-water in it.

Now add same amount of soap solution to which was added to tap water and shake vigorously. No lather will be produced. Add more soap solution and continue shaking. You will find that in the hard water instead of lather, scum is produced with soap solution.

Boil some hard-water. It will become soft and will give lather with soap solution readily.

Hard water can also be softened by adding washing soda to it.

6.11 Purification of Water

Water can be purified by several methods of which some are : decantation, filtration, boiling, distillation etc.

Decantation and Filtration :—When insoluble impurities are present in water, it is allowed to stand for sometime. Heavy particles of impurities settle down and pure water is decanted from above.

In order to separate fine particles, water is filtered. The process of filtration is shown in Fig. 6.10

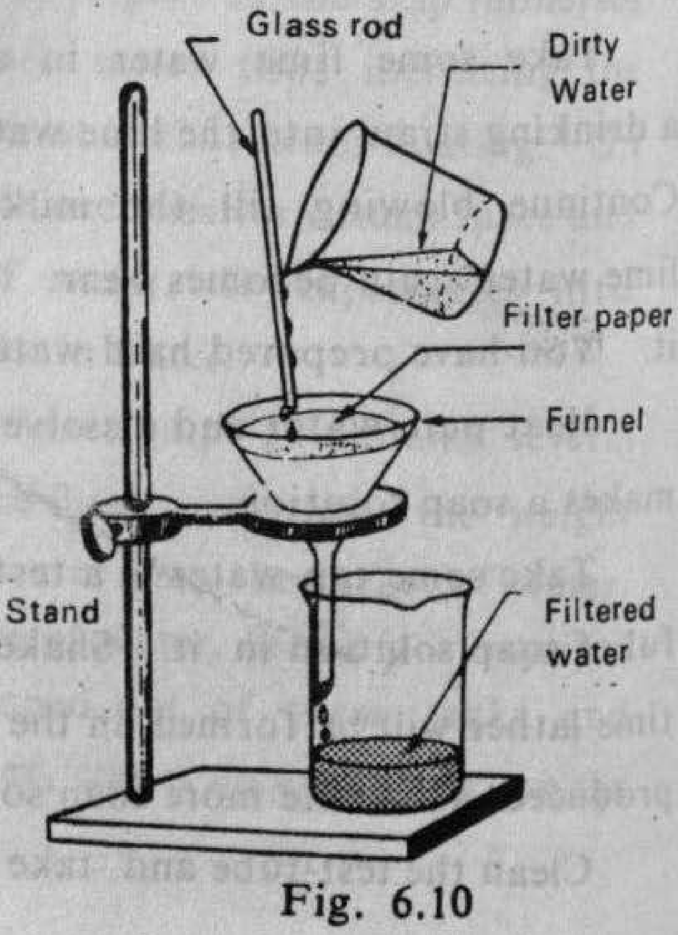


Fig. 6.10

Boiling :— Certain impurities like bicarbonates of calcium and magnesium become insoluble in water on boiling. The bacteria present in water are also killed by boiling. After boiling the water is decanted.

Distillation :—Some impurities like common salt do not become insoluble on boiling. Such impurities can be separated from water by the process of distillation.

Purification of Water on Large Scale

In order to purify water on large scale, the processes of boiling, distillation or filtration are very expensive. Therefore large scale purification of water is made by using a tank consisting of several layers of gravel, coal, sand etc. (Fig. 6.11). When impure water passes through such a tank

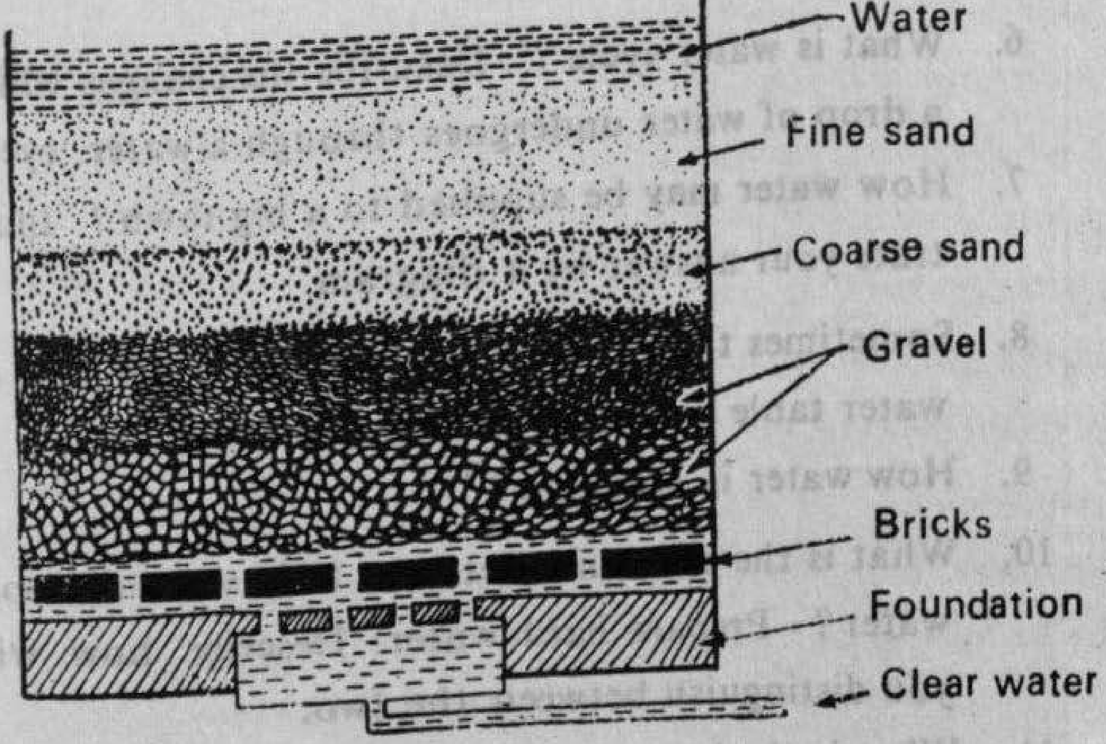


Fig. 6.11

the impurities become insoluble and are absorbed in the layers of sand, coal etc. Thus pure soft water is obtained.

Questions

1. What changes in weather take place due to evaporation of water ?
2. (a) What factors affect the evaporation of water ?
   (b) What factors affect the rate of condensation ?
3. Why is rain water pure ?
4. What is water-table ? Upon what factors does the height of water table depend ?
5. How are lakes formed ?
6. What is water cycle ? Describe the changes which a drop of water undergoes through a water cycle.
7. How water may be supplied to a big town ? Illustrate your answer by a diagram.
8. Sometimes the wells dry up. What is the state of water table during such a season ?
9. How water is softened ?
10. What is the difference between hard water and soft water ? Prepare hard water. Describe how will you distinguish between the two.
11. What is the level of ground water called ?

12. **What is water pressure ? What is its use in daily life ?**
13. **How are snow, dew, mist and frost formed ? What is the difference between these ?**
14. **How is weather forecast made ?**
15. **What instruments are used in weather forecast ?**

7

Matter & Energy

In earlier classses you studied that matter consists of tiny particles called *molecules* and that the molecules themselves are composed of even smaller particles called *atoms*. The atoms are so small that it is difficult to imagine them. Atom is so small that if each person were as small as an atom, the whole population of the world would easily fit in the hole of a needle. A gram of hydrogen gas has 600,000,000,000,000,000,000, 000 atoms of hydrogen. It is impossible to see such small particles directly. Scientists, however, have been able to photograph atoms separately by using special instruments.

For the last seventy years scientists are doing experiments which may throw some light on the structure of the atom. Lot of information is now available about the structure of the atom. On the basis of these informations we can draw a mental model of the atom. As more discoveries are made, our model of atom will also change accordingly.

Structure of Atom

Although atoms are very small but researches have shown that even these tiny particles have very complex structures. More than one hundred types of particle have been recognized inside the atom. In order to understand the structure of atom a knowledge of three basic particles will be enough for the time being. You will learn about other particles in higher classes.

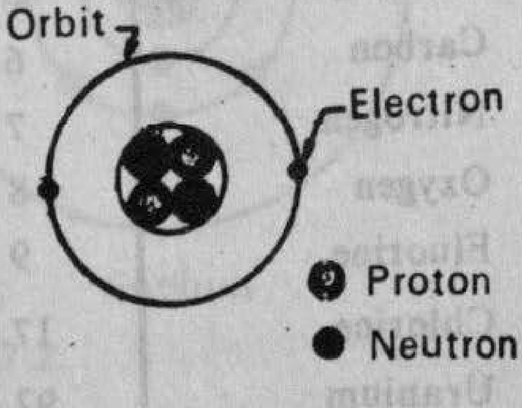


Fig. 7.1
Structure of helium atom

These three basic particles are *protons, neutrons and electrons*. Structure of helium atom is given in Fig 7.1 In this atom there are 2 protons, 2 neutrons and 2 electrons. Proton has positive electric charge and is found in the nucleus. Neutron is also found in the nucleus. Its mass is equal to that of a proton. Neutron is electrically neutral.

Electrons are found outside the nucleus. An electron has negative electric charge. The negative electric charge of the electron is equal to the positive electric charge of the proton.

Table 7.1 gives the number of protons, neutrons and electrons in some atoms.

Table 7.1 : Atomic Particles of some Atoms

Element	*Proton*	*Neutron*	*Electron*
Hydrogen	1	0	1
Helium	2	2	2
Lithium	3	4	3
Carbon	6	6	6
Nitrogen	7	7	7
Oxygen	8	8	8
Fluorine	9	10	9
Chlorine	17	18	17
Uranium	92	143	92

The quantity of matter or mass of an electron is only $\frac{1}{1837}$th of a proton or a neutron. In other words we may say that 1837 electrons together will equal one proton or neutron. Thus you can see that the electrons have negligible mass. The mass of the atom is concentrated in the nucleus.

Bohr Model of Atomic Structure

Structural models of a few more atoms are illustrated in Fig. 7.2. These models of atomic structure were first proposed by a Dutch scientist Niel Bohr. These models are, therefore, called Bohr models. In Bohr models neutrons and protons are shown in a central part called the *nucleus*. The electrons are shown revolving around the nucleus in fixed *orbits*. These orbits are called *electronic shells*. At the most two electrons can occupy the shell nearest to the nucleus. The second shell can have at the

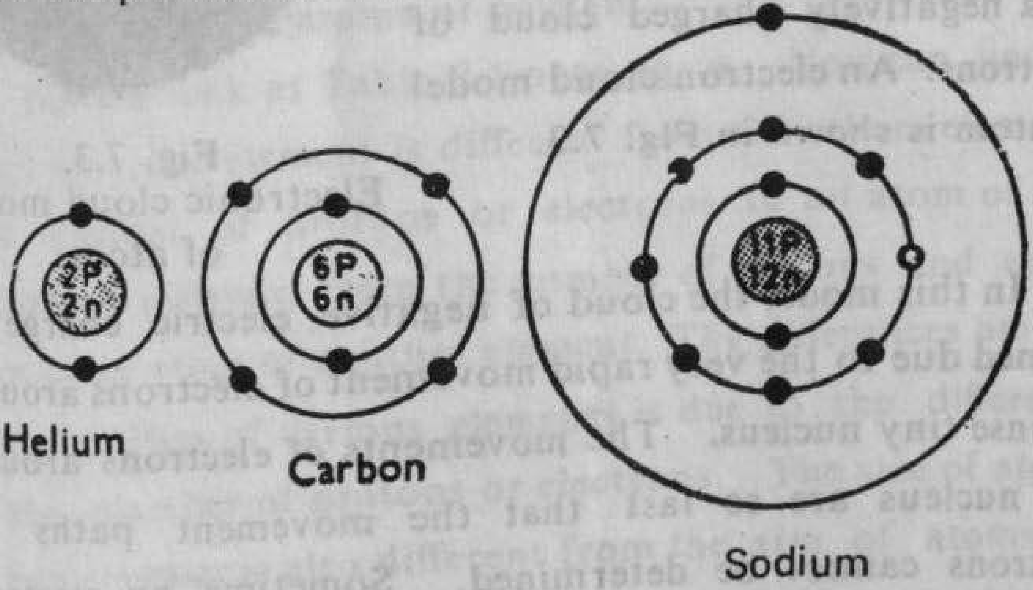


Fig. 7.2.

Bohr Model of few atoms.

most eight electrons. The number of electrons increases in the higher orbits. You will learn more about the rules governing the distribution of electrons in various shells in higher classes.

Electron Cloud Model.

A more advanced model of atomic structure is the *electron cloud model.* In this model atom is shown as a dense nucleus of protons and neutrons surrounded by a negatively charged cloud of electrons. An electron cloud model of atom is shown in Fig. 7.3.

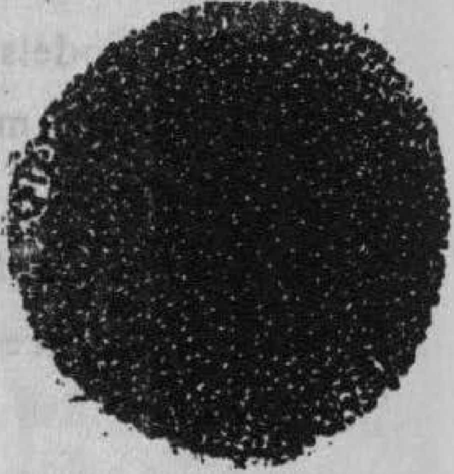


Fig. 7.3.
Electronic cloud model of atom.

In this model the cloud of negative electric charge is formed due to the very rapid movement of electrons around a dense tiny nucleus. The movements of electrons around the nucleus are so fast that the movement paths of electrons cannot be determined. Sometime an electron comes very close to the nucleus and sometimes it is found at a considerable distance from the nucleus. For most of the time, however, it is somewhere near its Bohr orbit. Thus in the electron cloud model we imagine the electrons like a diffused cloud of negative electricity around the nucleus.

Elements.

If a particular matter contains only one kind of atoms, it is called an *element*. For example in a piece of gold all atoms are similar. Gold is, therefore, an element. Similarly copper is an element because all atoms in a piece of copper are similar. Oxygen and nitrogen are two gases present in the air. They are also elements because in pure oxygen all atoms are similar and in a pure sample of nitrogen all atoms are also similar, although the atoms of nitrogen are different from the atoms of oxygen.

Have a look at Table 7.1 once again. You can understand why one element is different from the other element. The number of protons or electrons in an atom of one element is different from the number of protons and electrons in an atom of another element. The differences among the properties of various elements is due to the difference in the number of protons or electrons. The size of atoms of one element is also different from the size of atoms of another element. The size of all atoms of the same element is the same. Usually the atomic weight (or atomic mass) which represents the total number of neutrons and protons in a nucleus, is different for different elements.

Up till now, 105 elements have been discovered. Out of these about 90 elements occur naturally in the crust of the earth. The remaining elements have been artificially prepared by scientists in the laboratories. These artificially prepared elements are called the man made elements. Scientists in several countries are continuously working to prepare more elements. We may, therefore, expect that this number will increase.

Symbols of Elements.

A list of some naturally occuring elements is given in table 7.2. A chemical symbol of each element is also given against its name. It is easier to write the symbol instead of writing the full name of the element. Note the symbols of elements. The first letter of the symbol is always capital.

Table : 7.2 Some naturally occuring elements and their symbols

Element	*Symbol*	*Element*	*Symbol*
Aluminium	Al	Magnesium	Mg
Barium	Ba	Manganese	Mn
Boron	B	Mercury	Hg
Calcium	Ca	Nitrogen	N
Carbon	C	Oxygen	O
Chlorine	Cl	Phosphorus	P
Copper	Cu	Potassium	K
Gold	Au	Radium	Ra
Hydrogen	H	Sodium	Na
Helium	He	Sulphur	S
Iron	Fe	Titanium	Ti
Iodine	I	Uranium	U
Lithium	Li	Silver	Ag
Lead	Pb	Zinc	Z

Names of some elements prepared in the laboratories by scientists are given in Table 7.3 :

Table : 7.3 Some Man-made Elements and their Symbols

Element	*Symbol*	*Element*	*Symbol*
Astatine	At	Neptunium	Np
Curium	Cm	Mendlivium	Mv
Francium	Fr	Plutonium	Pu

Molecules of Elements

Many elements in nature do not occur as separate atoms. Instead they occur as molecules consisting of two or more atoms. For example, hydrogen gas is not made up of separate hydrogen atoms. It always consists of hydrogen molecules. The hydrogen molecule is represented as H_2. Hydrogen is stable only in the molecular form and not in the atomic form. When hydrogen is librated in a chemical reaction, it is produced as separate hydrogen atoms. But these separate atoms immediately combine to form molecules and we get molecular hydrogen and not atomic hydrogen. The formation of hydrogen molecules from the freshly librated atoms is shown 7.4.

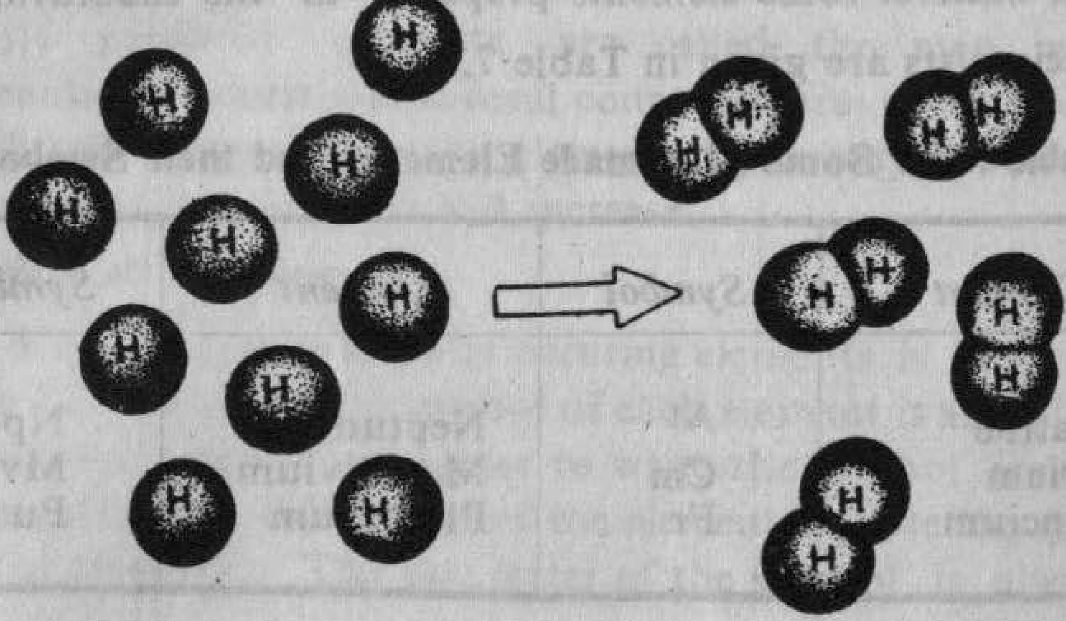


Fig. 7.4

Formation of hydrogen molecules from atoms of hydrogen :

In a hydrogen molecule, two atoms of hydrogen are chemically united with each other.

As atoms are represented by symbols, the molecules are represented by *formulas*. The formula of hydrogen molecule is written as H_2. The subscript shows that the molecule of hydrogen contains 2 atoms of hydrogen. Similarly we write the formula of nitrogen as N_2 because a molecule of nitrogen is made up of two atoms of nitrogen which are joined chemically with each other. A molecule of phosphorus contains four atoms of phosphorus and therefore its formula is P_4. By examining a chemical formula we can easily find out the number of atoms of a particular element in a molecule.

Compounds

Molecules of all kinds of substances, except those of elements, consist of atoms of different elements. For example, a molecule of water consists of two atoms of hydrogen and one atom of oxygen which have been chemically united with each other in a particular manner. A molecule of water is shown in Fig. 7.5. formula of water molecule is represented as.H_2O.

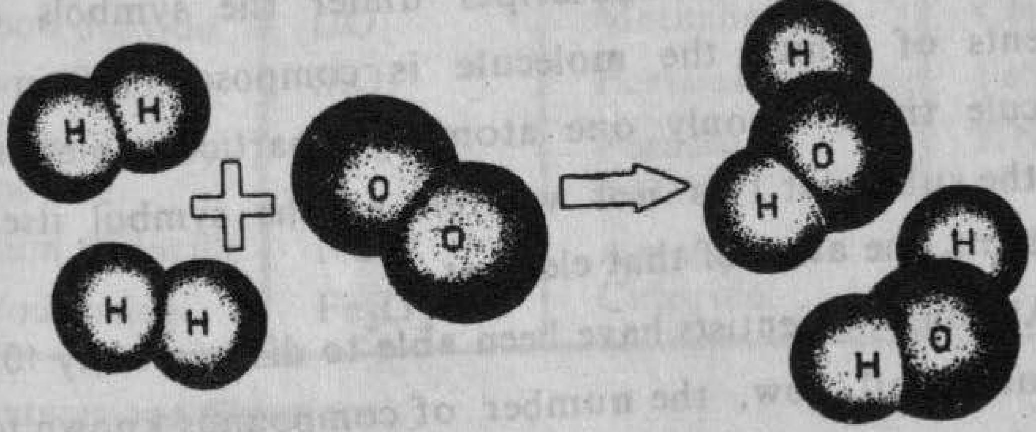


Fig. 7.5

Formation of two molecules of water from two molecules of hydrogen and one molecule of oxygen.

Substances whose molecules are made up of two or more atoms of different elements are called *compounds.* Thus water is a compound of hydrogen and oxygen. A molecule of water is composed of two atoms of hydrogen and one atom of oxygen which are chemically united with each other. A molecule of ammonia is composed of three atoms of hydrogen and one atom of nitrogen. Ammonia molecule is represented by the formula NH_3. Ammonia is also a compound as its molecule is composed of two different kinds of elements.

In writing a formula of a compound the number of atoms are written as subscripts under the symbols of elements of which the molecule is composed. If in a molecule there is only one atom of a particular element then the subscript 1 is not written as the symbol itself represents one atom of that element.

Although Scientists have been able to discover only 105 elements uptil now, the number of compounds known to have been made by these elements runs into millions. Chemists are continuously preparing and discovering new compounds and for most part their work relates to the study of properties of these compounds. Most of the substances around us are compounds. For example, all substances that we eat, different kinds of clothings, wood, medicines and all plant and animal materials are compounds. The formulae and structures of most of the compounds are quite complex. Some compounds are, however, simple as well. Formulae of some compounds are given in Table 7.4. Find out the elements and the number of atoms in the formulae of compounds given in Table 7.4.

Table 7-4 Some Compounds and their Formulae

Compound	*Chemical formula*	*Compound*	*Chemical formula*
Calcium carbonate	$Ca\ CO_3$	Sulphuric acid	H_2SO_4
Sugar	$C_{12}H_{22}O_{11}$	Nitric acid	$H\ NO_3$
Carbon dioxide	CO_2	Methane	CH_4
Silicon dioxide	SiO_2	Ferrous sulphide	FeS
Sodium Carbonate	Na_2CO_3	Potassium-nitrate.	KNO_3
Sodium Chloride	$NaCl$	Ammonium Chloride.	NH_4Cl
Ferrous oxide	Fe_2O_3		

Mixtures and Solutions

Substances all around us are either elements or compounds. But pure elements or pure compounds are hard to find. Most of the substances are actually mixtures of two or more elements or compounds. *A mixture is a substance which contains two or more elements or compounds mixed together in such a way that each compound retains its individual properties.* The molecules of each compound in a mixture remain as such.

A well known mixture is air that exists all around us. Although we tend to think of air as a simple substance but it is actually a mixture of several gases like nitrogen, oxygen, argon, carbon dioxide and water vapour. All these gases can be separated.

If you mix powdered salt and powdered sugar, it will form a mixture. Taste this mixture and you will at once notice the tastes of both sugar and salt separately. If you mix sand in water, it will also make a mixture. You can easily separate water and sand by filtering this mixture through a piece of cloth. Water will pass through the piece of cloth, whereas sand will remain on the cloth. The constituents of a mixture can usually be separated easily.

You can easily understand the difference between a compound and a mixture by performing the following experiments.

Experiment—1

Take a spoonful of powdered sulphur in a porcelain dish and mix in it an equal amount of iron filings. Observe the mixture carefully. You will see particles of iron and sulphur lying side by side. Stir the contents with a magnet. All the particles of iron will stick to it leaving behind sulphur in the dish.

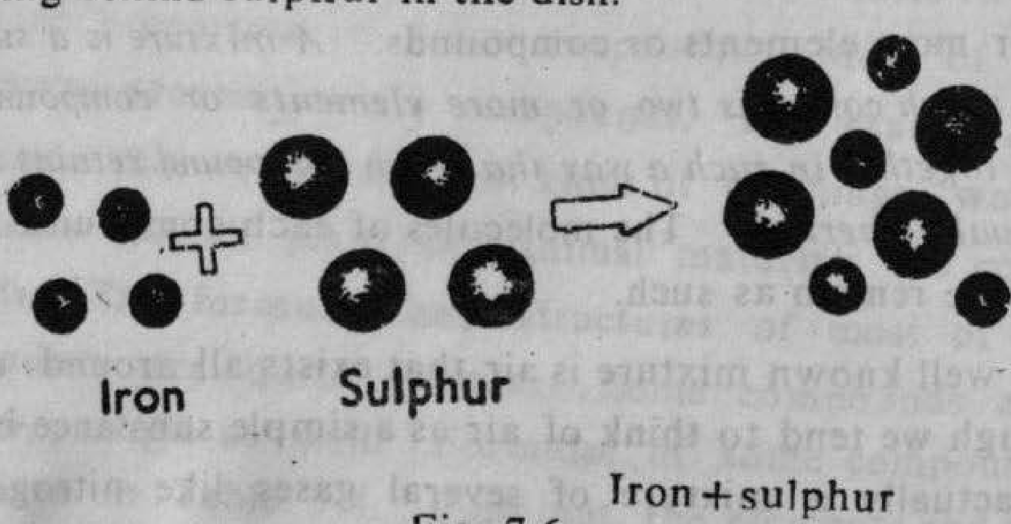


Fig. 7.6
Mixture of iron and sulphur.

Experiment 2: Again mix iron filings and powdered sulphur thoroughly in the dish and heat the dish on a spirit lamp flame. After some time the contents in the dish will begin to glow, and on cooling a black substance will be left. Observe this black substance with the help of a convex lens carefully. Do you now see iron particles and sulphur particles lying side by side. Powder this black substance and stir it with a magnet. The particles of this black substance will not stick to the magnet. When sulphur and iron are heated, the components of the mixture undergo a chemical reaction. We say a chemical change takes place and a new substance is formed. In a chemical change the atoms of different elements combine chemically. The properties of this substance are different from the properties of either sulphur or iron. This substance is a compound called ferrous sulphide The formula of this compound is FeS.

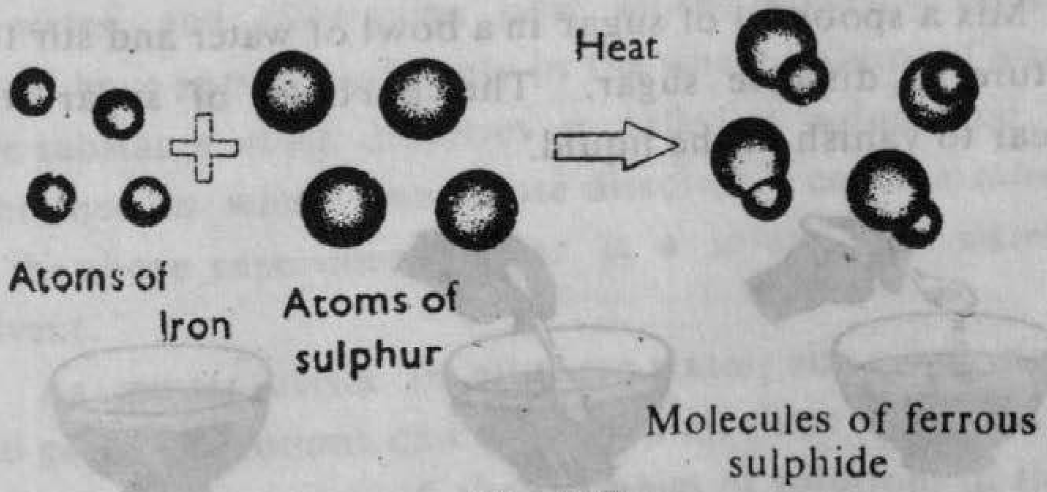


Fig. 7.7

Formation of a compound of sulphur and iron.

We may represent the formation of a mixture in the Experiment 1, and the formation of a compound in Experiment 2 as in Fig. 7.6 and Fig. 7.7 respectively.

Solutions :

A solution is a mixture of two or more substances in which the molecules of each substance are uniformly dispersed in the whole volume of the mixture. No particle in a solution is greater than the molecular size. Syrup of sugar, salty water and water containing dissolved air are all examples of solutions. The formation of a solution is a physical change. No chemical change takes place when a solution is formed.

Experiment.

Mix a spoonful of sugar in a bowl of water and stir the mixture to dissolve sugar. The particles of sugar will appear to vanish in the liquid.

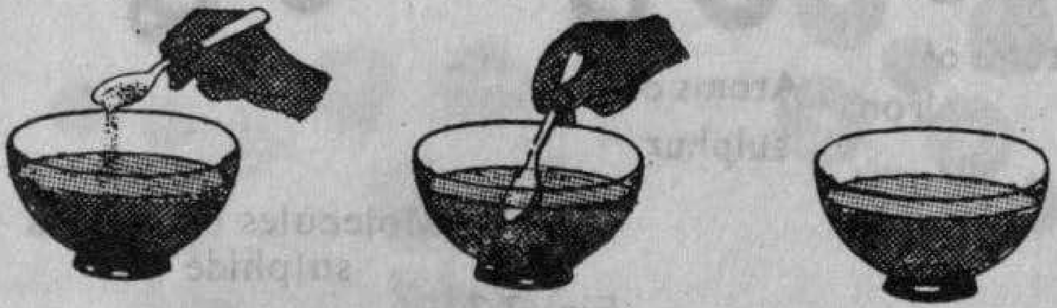


Fig. 7.8
Preparation of solution of sugar in water.

Now taste this solution. You can easily recognize the

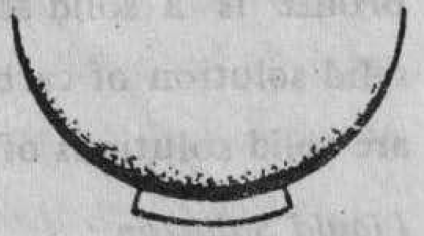


Fig. 7.9

Evaporation of a solution leaves the solid solute behind.

taste of sugar in the solution. In a solution the components of the solution retain their properties.

Suppose you want to separate sugar from water. What would you do? Just leave the solution in the open for a few days. Water will evaporate and the sugar will be left sticking to the walls of the bowl. If you don't want to wait that long, transfer the solution in a metallic pan and heat it on a low flame, water will boil off leaving behind the dissolved sugar.

If you could see the molecules of sugar in the above experiment, you would have observed molecules of sugar separating from the solid crystals of sugar and dispersing in water, and after some time all the molecules of sugar would have spread uniformly in the whole volume of water. The substance which dissolves is called a *solute* and the substance in which the solute dissolves is called a *solvent*. In the above experiment sugar is a solute and water a solvent.

As matter exists in all three states, viz., solid, liquid and gas, the solutions can also be in all these three states. Following are some of the examples of solutions in these three states.

Solid Solutions :

Alloys of metals are examples of solid solutions. For example, brass is a solid solution of copper and zinc

Bronze is a solid solution of copper and tin, and steel is a solid solution of carbon and iron. Some very hard steels are solid solutions of iron and tungsten metals.

Liquid Solution :

Sugar syrup, salty water and tincture iodine (iodine in alcohol) are liquid solutions.

Gas Solutions :

Air is a gaseous solution. Similarly air in which some sweet smelling or foul smelling matters are mixed are also gaseous solutions.

Solutions play a very important role in the life of animals and plants. Important components or nutrients of our food dissolve in the blood which carries them to all parts of our bodies where they help in the repair of body tissues and in the building of new cells. Plants absorb their nutrients from the solutions in the soil. Most of the chemical reactions occur when the reacting substances are in the solution form.

Acids, Bases and Salts

In the preceding sections you have studied that there are only 105 elements with which this universe is constituted. Scientists like to call these elements as the building blocks of universe. Every material thing in this universe is composed of these elements or their millions of compounds. In order to understand these millions of compounds, we can classify them into groups. Let us try to survey these groups in order to understand their nature.

For our survey we will need a dry cell or battery, a length of copper wire, an electric bulb in a holder, a spirit lamp, a beaker and a china crucible. In our survey we will include the following substances ; distilled water, table salt (Na Cl); sodium bisulphate (Na HSO_4), kerosene oil, caustic soda or sodium hydroxide (NaOH), sulphuric acid (H_2SO_4), wax and sugar.

Arrange the apparatus as shown in Fig. 7.10. Connect the terminals of the battery with two copper wires and an electric lamp in series. Dip the open ends of the wires in distilled water kept in a beaker in such a way that the two wires do not touch each other. You will observe that the electric bulb does not light up because distilled water does not allow electric current to pass through. Repeat this experiment by taking the solutions of sodium chloride, sugar, sodium hydroxide, sodium bisulphate, sulphuric acid and kerosene oil. You will find that solutions of sulphuric acid, sodium bisulphate, sodium hydroxide and

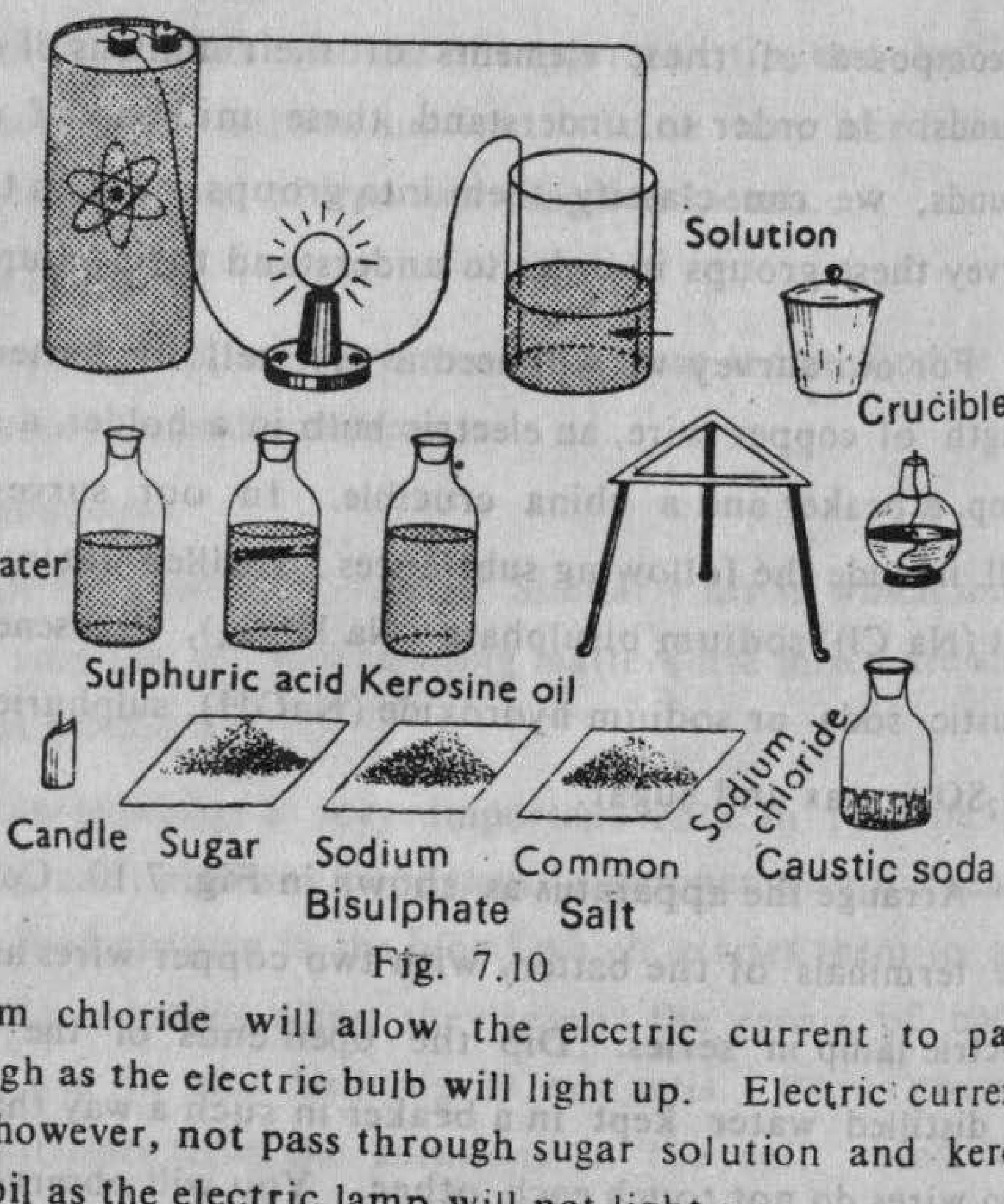

Solution
Crucible
Water
Sulphuric acid
Kerosine oil
Sodium chloride
Candle
Sugar
Sodium Bisulphate
Common Salt
Caustic soda

Fig. 7.10

sodium chloride will allow the electric current to pass through as the electric bulb will light up. Electric current will, however, not pass through sugar solution and kerosene oil as the electric lamp will not light up.

Now melt sodium bisulphate, caustic soda, sodium chloride and wax in the crucible and again dip the ends of the wires in these molten substances one by one. (You may not be able to melt sodium chloride over a spirit lamp because it melts at high temperature. Other substances will, however, melt easily). You will find that molten caustic soda, sodium sulphate and sodium chloride allow the current to pass through but wax does not.

Thus we may divide the substances into two groups :

(i) Those substances which in solution or molten state allow the electric current to pass through. These substances are called *electrolytes*. Sodium chloride, sodium hydroxide, sodium bisulphate and sulphuric acid are electrolytes.

(ii) Substances which in the solution or molten state do not allow the electric current to pass through are called *non-electrolytes*. Thus wax, kerosene oil and sugar are non-electrolyte. Water is another example of non-electrolyte.

Electrolytes are further divided into three groups: Acids, bases and salts. You can recognize acids, bases and salts by the following experiment.

Experiment

Take three empty beakers. In one put some solution of sodium chloride (NaCl), in the second beaker put some solution of sodium hydroxide (NaOH) and in the third a solution of sulphuric acid. Now add few drops of blue litmus solution in each of the beakers. You will observe that the colour of sodium chloride and sodium hydroxide remains light blue, whereas, the colour in the sulphuric acid changes to light red. Thus sulphuric acid turns the colour of blue litmus into red.

Throw out these solutions, wash the beakers with water and again take these solutions in these beakers.

Now add few drops of red litmus in each of these solutions. You will find that the colour of the sodium chloride and sulphuric acid remain light red but sodium hydroxide changes the red litmus into blue. Red or blue litmus do not change their colour in the solution of sodium chloride.

Electrolytes that turn blue litmus red are called acids. Thus sulphuric acid is an acid.

Electrolytes that turn red litmus blue are called *bases.* Thus sodium hydroxide is a base.

Those electrolytes which have no action with litmus are called *salts.* Thus sodium chloride is a salt. Litmus is a pigment obtained from plants and is used for the identification of acids and bases. Some other substances are also used for identification of acids and bases. Phenolphthalein is one such substance which turns red in bases but in acids it becomes colourless.

Let us study some common properties of acids :

(i) All acids have sour taste.

(ii) All acids in water turn blue litmus red.

(iii) Most of the acids corrode metals.

(iv) The molecules of all acids contain atoms of non-metals only.

Some common acids and their chemical formulae are given in table 7.5.

Table 7.5 : **Some acids and their chemical formulae**

S. No.	*Acid*	*Formula*
1.	Acetic acid	$HC_2H_3O_2$
2.	Carbonic acid	H_2CO_3
3.	Hydrochloric acid	HCl
4.	Sulphuric acid	H_2SO_4
5.	Nitric acid	HNO_3

Note the formulae of all these acids. You find that hydrogen is present in all these compounds.

All bases also have some common properties. These properties are as under :

(i) All bases have bitter taste.

(ii) When rubbed between fingers; all bases feel slippery.

(iii) All bases or their aqueous solutions turn red litmus blue.

(iv) All bases can dissolve vegetable oils and animal fat.

Some bases and their formulae are given in table 7.6.

Table 7.6 : **Some bases and their chemical formulae**

S.No.	*Base*	*Formula*
1.	Calcium hydroxide	$Ca(OH)_2$
2.	Caustic soda or sodium hydroxide	$NaOH$
3.	Caustic potash or potassium hydroxide	KOH
4.	Ammonium hydroxide	NH_4OH

Note the chemical formulae of all these bases. All bases contain hydroxide (OH) group.

Experiment

Take a dilute solution of caustic soda in a beaker. Add a drop of phenolpthalein in this solution. It will turn red. Now start adding a dilute solution of hydrochloric acid drop by drop. Go on stirring the solution while mixing hydrochloric acid. As soon as the red colour disappears, stop adding hydrochloric acid. Now transfer this solution in an evaporating dish and heat it on a spirit lamp flame. Water will boil off and a white solid will be left behind. Taste this solid. What do you find ?

Dissolve a small amount of this solid in water in a test tube and test the solution with a red litmus paper and then with a blue litmus paper. Do you find any change in the colour of litmus papers ?

The above experiment will show that when an acid reacts with a base, a new substance is formed which has no action with litmus, The substance formed by the reaction of an acid with a base is called a *salt*. In addition, water is also formed. The salts are neutral towards litmus.

Some salts and their chemical formulae are given below :

Table 7.7 : Some salts and their formulae

S. No.	*Salt*	*Formula*
1.	Sodium chloride or table salt	$NaCl$
2.	Magnesium sulphate	$MgSO_4$
3.	Copper sulphate	$CuSO_4$
4.	Potassium nitrate	KNO_3

Salts are very important for the life processess of plants and animals. Most of the minerals that our body needs for various biological functions are salts. Potassium nitrate present in the soil is essential for the growth of plants. But if the soil contains too much of this salt, it causes salinity and you know that salinity makes soil unfit for the growth of plants.

Minerals

Minerals are all those substances that have a definite chemical composition and are produced in the crust of the earth due to natural processes. Naturally occuring metals and their ores (compounds from which metals are extracted), sulphur, salts, coal, petroleum, natural gas are all minerals.

Sometimes, we find minerals concentrated in a particular place in the earth. We then dig mines to get these minerals and use them for various purposes. But in many cases these minerals are so widely dispersed in the earth and mixed with rocks and soil that the separation of these minerals from unwanted matters becomes extremely difficult and costly. For example aluminium is present in the earth's crust to the extent of 8%. But inspite of this huge quantity it is very difficult to separate it. We, therefore, search for deposits of aluminium ores in which the metal is present in higher quantity. The extraction of aluminium will only be economical from relatively pure deposits of aluminium. Chemists throughout the world find it a great challenge to search for new minerals and get metals from them. In our country lot of efforts are being made to develop our mineral resources and to extract metals from these minerals and ores. Some useful minerals found in Pakistan are described below.

Sodium Chloride or Rock Salt

It is an important component of our food. Salt mines are situated in Khewra and Kohat. Salt is also obtained by evaporation of sea water. Oceans are very large reservoirs of useful minerals. Sea water contains about 3 percent of sodium chloride, besides many other salts.

Lime Stone

Lime Stone is calcium carbonate ($Ca\ CO_3$). On heating it is converted into lime or calcium oxide (CaO). Lime is used in the manufacture of cement and for white washing. It is also used in the preparation of glass. Deposits of lime stone are found in N.W.F.P. and the northern parts of Punjab.

Marble

Marble is also a form of calcium carbonate ($Ca\ CO_3$). It is an important building material. Marble mines are situated in Baluchistan and N.W.F.P.

Gypsum

The chemical formula of gypsum is $Ca\ SO_4.2\ H_2O$. Its deposits are found in northern parts of Punjab. It is used in the preparation of white cement and in the manufacture of chemical fertilizer.

Chromite

Chromite is actually ferrous chromite Fe (CrO_2) Chromium metal which is used for the preparation of stainless steel is extracted from this mineral. It is also a starting material for the preparation of many chromium compounds which are used in tanning and textile. Deposits of chromite minerals are found in Hindu bagh and Chaghi district. It is also found in Wazirastan and Tangi in N.W.F.P.

Coal

Coal is an impure form of carbon. It is believed that coal has been formed from the forests that were burried thousands of years ago under earth. By slow decomposition of the wood of forest, coal was formed. There is a scarcity of good quality coal in Pakistan and we have to import coal from abroad for making steel and for extraction of metals. Native deposits of coal are used as fuel in brick kilns. Coal mines are situated at many places in Punjab and Baluchistan.

Iron

Iron is not found in the free state. Its important ores are magnetite (Fe_3O_4) and haematite Fe_2O_3. These ores are found at Kalabagh and Chitral.

Mineral Oil or Petroleum

Petroleum is a mixture of many hydrocarbons (compounds of carbon and hydrogen). Petroleum obtained from oil wells is purified or refined to get diesel oil, mobil oil, kerosene oil and petrol. There are many oil wells in northern districts of Punjab. Oil from these wells is brought in the oil refinery at Rawalpindi where it is refined to get petrol, kerosene, diesel oil, mobil oil and grease etc.

Natural Gas

Natural Gas is also a mineral. It is a mixture of many gases but 94% of it is methane or CH_4. Most of the natural gas in Pakistan is obtained from Sui Gas Fields in Baluchistan. Large deposits of this gas are also present under ground at various places in Sind.

Matter and Energy

So far you have been studying matter and energy separately. You know that energy exists in many forms, e.g., kinetic energy, potential energy, chemical energy, heat energy, light energy, electric energy......etc., but the concept of energy cannot be appreciated without the concept of matter. All the different forms of energy can only be studied by the different changes brought about by them in matter. Energy is either given out or absorbed during every change occuring in matter. The conclusion which we can draw from these observations is that matter and energy are deeply inter-related.

Although matter changes its form as a result of interaction with energy yet it is our experience that the total mass of matter remains constant. It is also true about energy which may change its form from one to another, but the total amount of energy remains constant. For example the kinetic energy of running water may be changed into electrical energy by means of electric generators, but the total energy remains the same.

We can conclude from these observations that there is a common property of matter and energy. That is, both these can neither be created nor destroyed. They can, however, be changed from one form to another.

Scientists have been considering the relation between matter and energy since long. In 1905 Einstein expressed the relation between matter and energy by his well known equation.

$$E = mc^2$$

$$\text{Energy} = \text{mass} \times (\text{speed of light})^2$$

This equation shows that a very small quantity of matter is equivalent to a very large amount of energy because the mass of matter which is converted into energy is multiplied by the square of speed of light. You know that the speed of light is equal to 30,000,000,000 cm per second.

Einstein's equation tells us that matter can be converted into energy and energy can be condensed into matter or in other words we can say that the matter and energy are, in fact, the two names of the same quantity.

Let us compute the energy produced when one gram of matter is completely converted into energy. We have

$$E = mc^2$$

Substituting the value of $m=1$ gm and $c=30,000,000,000$ cm per second we get

$$E=1 \text{ gm} + (30,000,000,000 \text{ cm/second})^2$$

This quantity of energy is equal to 25,000,000 kilowatt hours.

Atomic energy

We can study the conversion of matter into energy by those reactions in which the nuclei of atoms are broken up. During these nuclear reactions, as they are called, a large quantity of energy is evolved. This energy is known as *nuclear* or *atomic energy*. The energy produced by atomic bombs or atomic reactors is due to these nuclear reactions.

It is not easy to break the nucleus of an atom by any means. An atom cannot be broken by any chemical reaction. In fact we need very fast moving bullets for breaking the nuclei and even these bullets are effective in the case of heavy nuclei e.g., uranium. These fast moving bullets are neutrons. For example when a neutron hits a heavy nucleus of uranium consisting of 235 particles (92 protons and 143 neutrons), it is split up into two parts Splitting up of heavy nucleus into smaller parts is known as *atomic fission*.

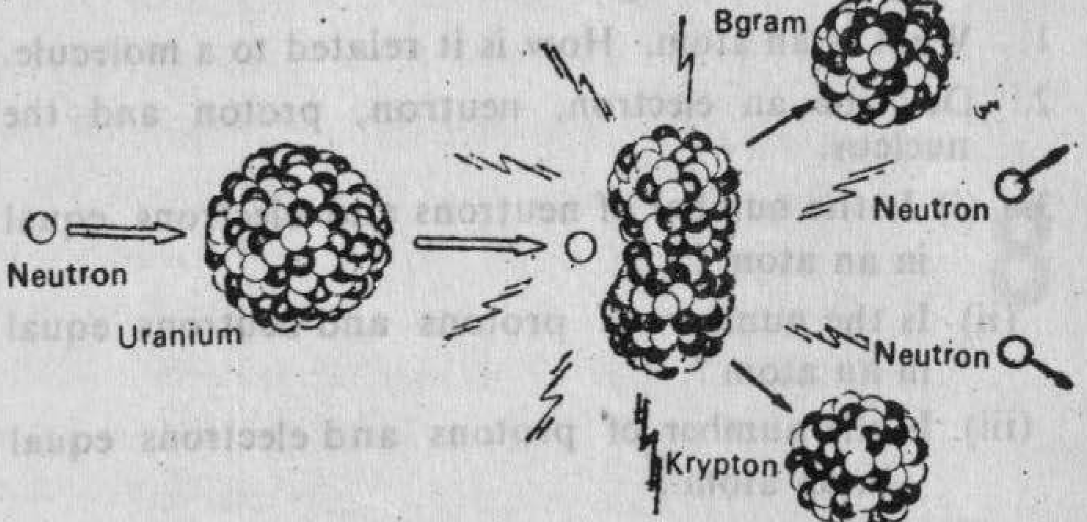


Fig. 7.11
Fission of a uranium atom

The total mass of the smaller parts is little less than the mass of heavy nucleus which has undergone fission. This loss of mass is coverted into energy. In the fission of a uranium nucleus, krypton, barium, and few neutrons are formed. These neutrons in turn, cause fission in other nuclei of uranium, In this way a chain reaction starts which stops only when all the uranium nuclei have undergone fission. The energy evolved during fission process is in the form of heat and light. The amount of heat produced during the explosion of an atomic bomb can be judged by the fact that for some time the temperature in the middle of the bomb rises to 20,000,000°C.

This huge source of energy can be used for either destructive or peaceful purposes. It can be used to eradicate the nations and countries from the map of the world and it can be utilised for the welfare of the human race.

Questions

1. What is an atom. How is it related to a molecule.
2. Describe an electron, neutron, proton and the nucleus.
3. (i) Is the number of neutrons and electrons equal in an atom ?
   (ii) Is the number of protons and neutrons equal in an atom ?
   (iii) Is the number of protons and electrons equal in an atom ?
4. Describe a Bohr model of atom. Where are the electrons in the atom according to this model.
5. Describe an electron cloud model of atom. How is the movement of electrons according to this model different from the movement of electrons according to Bohr model.
6. An atom of nitrogen has 7 electrons, 7 protons and 7 neutrons. Draw a Bohr model of this atom. What is the atomic weight of nitrogen.
7. How is an electron different from a proton ?
8. Is the neutron more like an electron or a proton ?
9. How are elements, compounds and mixtures different from one another ? Is solution a compound or a mixture ?
10. What is a chemical formula ? Write chemical formulae of three substances that you know.
11. The chemical formula of soap is $C_{17}H_{35}COONa$. How many atoms are present in one molecule of soap ? What elements are present in soap ?

———

8

Oxygen, Hydrogen AND Carbon Dioxide

The solid, liquid and gaseous matter of earth consists of millions of different chemical substances. The chemical composition of most of these substances is quite complex. In fact the composition of a very large number of these substances is yet to be determined. The molecules of gases are, however, quite simple because they are usually small and the chemical structure of the gas molecules is comparatively easy to determine. In this chapter we shall study the chemistry of some important gases of the atmosphere.

Composition of Air

You have already studied that air is a mixture of many gases. The percentage composition of these gases in the atmosphere is not constant every where. It changes from place to place and at the same place from time to time. For example, the amount of water vapours in air at a place increases after rain. If there is no rain for several weeks at a place, the air gets dry. The amount of water vapours depends on local conditions. On oceans, lakes and on adjoining land areas, the amount of water vapours is usually more than on dry and desert areas which are far removed from large masses of water. The amount of water vapours in air also depends on the temperature. Hot air can hold more water vapours than cold air.

As the variation in the amount of water vapours at a place is usually large, the geochemists are often interested only in the composition of dry air. An analysis report of a sample of dry air is given below :

Analysis Report of a Sample of Dry Air

Gas	*Formula*	*Percentage of molecules*
Nitrogen	N_2	78.09
Oxygen	O_2	20.93
Argon	Ar	0.93
Carbon dioxide	CO_2	0.03
Hydrogen	H_2	0.00005

In addition to the above mentioned gases air also contains a small amount of molecules of some other elements and compounds. But this amount is usually negligible.

If you carefully study the above report, you will find that the amount of hydrogen is extremely small. This is because hydrogen molecules, being very light, are pulled with very little gravitational force of attraction by the earth. Due to this small gravitational pull, the earth could not keep the molecules of hydrogen from escaping from the atmosphere. It is, therefore, believed that when earth was created there was a large amount of hydrogen in its atmosphere which then escaped and was lost in outer space.

You can find another important fact in the report that most of the gases in the air are elements. Only carbon dioxide is a compound.

Oxygen

Oxygen is not only present in air but also in solid crust of the earth and in water. In the matter of earth's crust oxygen is present to the extent of 60.5 percent. In water the percentage of oxygea is 88.89%

Preparation of Oxygen

As air contains elemental oxygen, we can separate this gas from air, although it is easier said than done. In order to separate oxygen from air we must first cool air to a temperature of about—200°C to convert it into liquid. The liquid air contains only nitrogen and oxygen. Argon does not liquify even at this temperature. When liquid air is evaporated, nitrogen, being more volatile than oxygen, leaves first. The remaining liquid after the removal of nitrogen is almost pure oxygen. This method of getting oxygen is used on commercial scale. It is, however, difficult to prepare oxygen in the laboratory by this method.

Laboratory Preparation of Oxygen

You can easily prepare pure oxygen in your school laboratory by heating a compound known as potassium chlorate ($KClO_3$). Potassium chlorate is a white solid. If you heat some potassium chlorate in a test tube, the compound will first melt and then start decomposing with the evolution of bubbles of oxygen. You can test oxygen by bringing a smouldering match stick at the mouth of the test tube. The smouldering match stick will burst into flame. *Bursting into flame of a smouldering match stick is a test of oxygen gas.* Although air also contains oxygen but in air a smouldering match stick does not light up because air contains large amount of nitrogen which slows down the burning action. In pure oxygen the burning action is very fast, therefore, the smouldering match stick lights up.

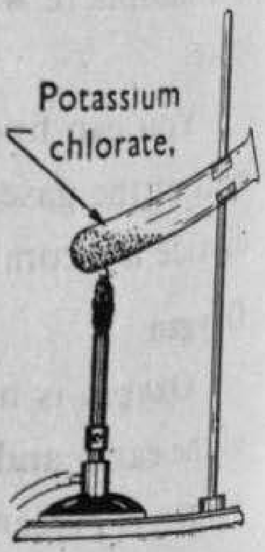


Fig. 8.1

We can represent the reaction of production of oxygen from potasssium chlorate as under :

$$\text{Potassium chlorate} \xrightarrow{\text{heat}} \text{Potassium chloride} + \text{oxygen}$$

This reaction can also be represented by chemical formulae e.g.,

$$2KClO_3 \xrightarrow{\text{heat}} 2KCl + 3O_2$$

The arrow head in this reaction represents the direction of the chemical reaction. Note the reaction carefully. You will find that the number of atoms of different elements on both sides of the arrow head are equal. That is why, a chemical reaction when written in this manner is called a chemical equation. The numeral 2 before $KClO_3$ tells us that two molecules of $KClO_3$ are being decomposed. Similarly 2KCl means that two molecules of potassium chloride are produced, and $3O_2$ shows that 3 molecules of oxygen gas are liberated by the decomposition of 2 molecules of $KClO_3$.

If you wish to get oxygen from potassium chlorate alone, you will have to heat this compound for a long time. But if you mix some manganese dioxide with potassium chlorate in a test tube and then heat the mixture, the oxygen gas will readily come out at a lower temperature (about 250°C). The speed of production of oxygen gas will also accelerate. Manganese dioxide does not itself take part in the chemical reaction. It only makes it easier for $KClO_3$ to give up oxygen ; i.e., it only speeds up the reaction. Substances that do not take part in the chemical reaction but only speed-up the reaction are called *catalysts.*

Method for collecting gas

In order to study the properties of oxygen, we must collect the gas in a bottle. For this we will have to remove air from the bottle. The simplest way is to fill the bottle with water so that the air is removed. After covering the mouth of the bottle with a lid, invert it over a beehive shelf in a trough of water as shown in Fig. 8.1 :

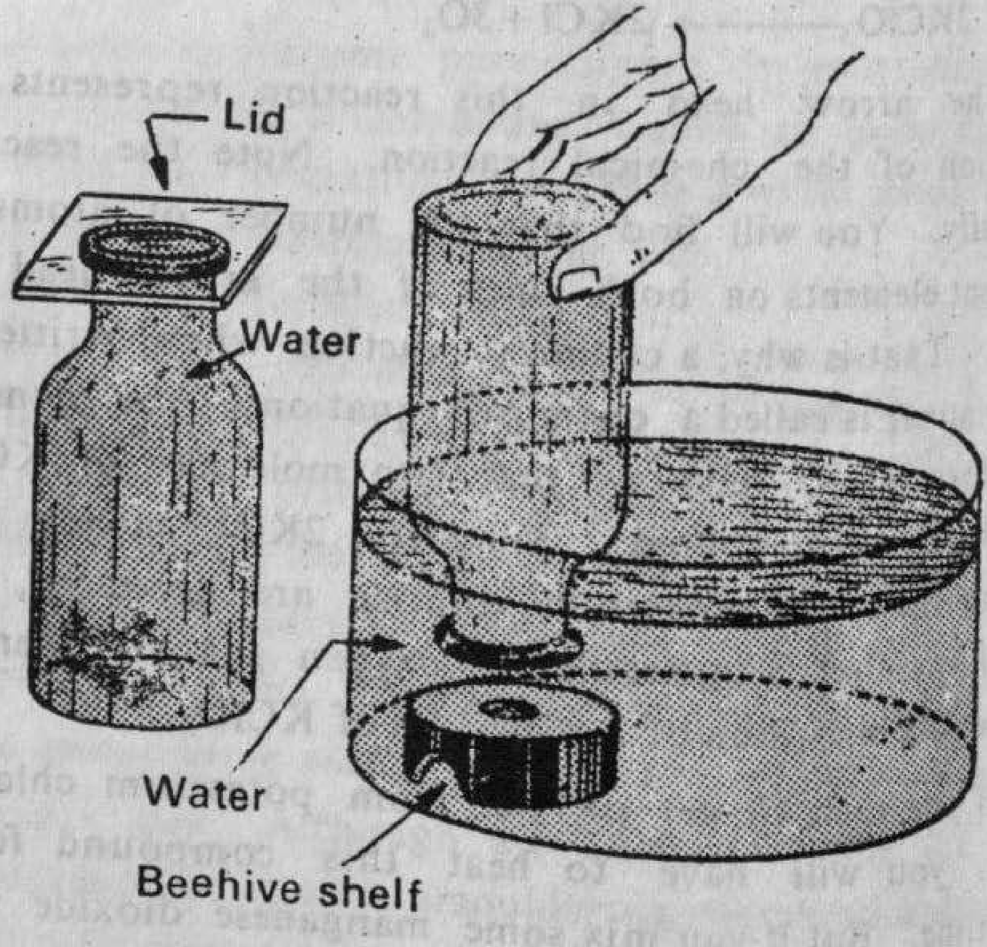


Fig. 8.1

If now a gas enters through a delivery tube placed under the beehive shelf, the gas bubbles will be seen to rise through the upper hole of the beehive shelf into the bottle. The water in the bottle will descend and the gas will take its place. Thus the bottle will be filled with gas.

Experiment.

For preparing oxygen gas from potassium chlorate, mix 4 parts of potassium chlorate $KClO_3$ with one part of manganese dioxide (MnO_2). Thoroughly mix these two substances and then fill about one fourth of a test tube with this mixture. Put a cork with a hole and a delivery tube in the mouth of this test tube and then fix the test tube in a stand with the help of a clamp. The other end of the delivery tube should be immersed in water in the trough under a beehive shelf as shown in Fig 8.2

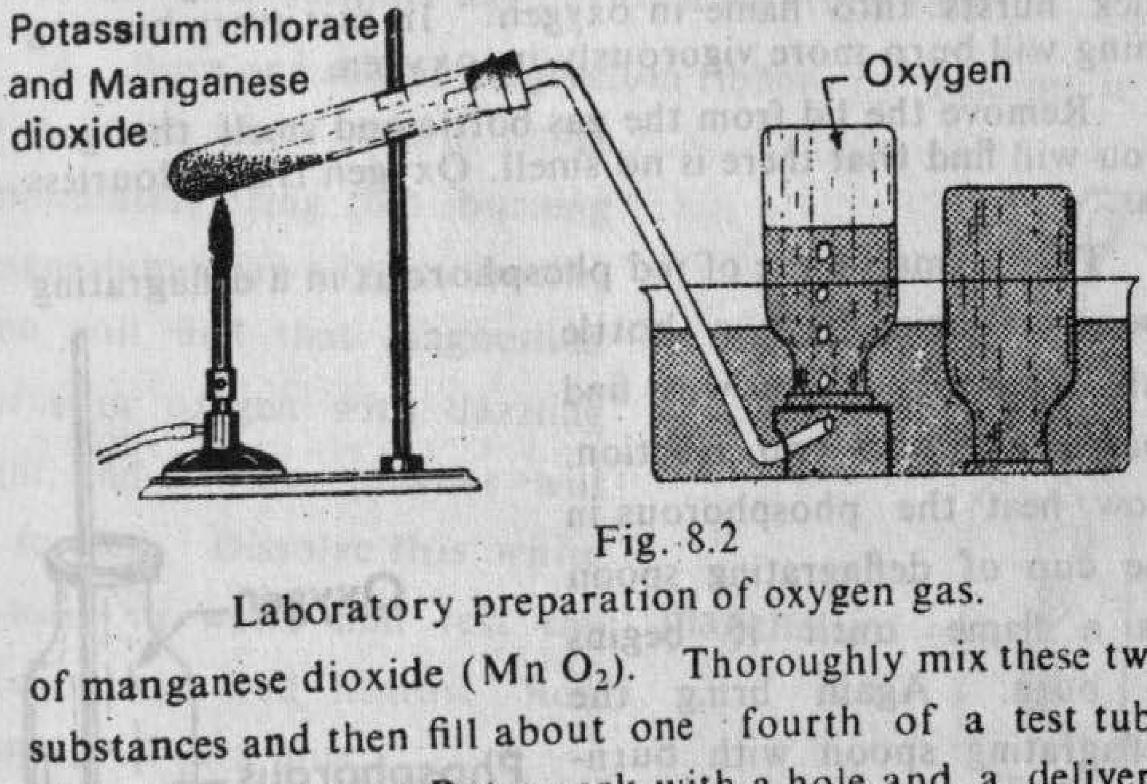


Fig. 8.2

Laboratory preparation of oxygen gas.

Heat the test tube with a spirit lamp. Let the gas bubble out of water for a few seconds because this gas is not pure oxygen and it contains air of the test tube and the delivery tube. Now put the inverted bottle of water on the beehive shelf. The bubbling gas will rise up in the bottle displacing water downward. When the bottle is filled with gas, put a lid on the mouth of the bottle while it is still immersed in water. Now you may bring the bottle out of the trough because the mouth of the bottle is closed with the lid and the gas will not escape. Fill a few bottles with oxygen and study the properties of the gas.

Properties of Oxygen.

You have already studied that smouldering match stick bursts into flame in oxygen. In fact every burning thing will burn more vigorously in oxygen.

Remove the lid from the gas bottle and smell the gas. You will find that there is no smell. Oxygen is an odourless gas.

Take a small piece of red phosphorous in a deflagrating spoon and bring it in a bottle full of oxygen. You will find that there is no reaction. Now heat the phosphorous in the cup of deflagrating spoon on a flame until it begins to burn. Again bring the deflagrating spoon with burning phosphorous in the bottle of oxygen. You will find that this time phosphorous burns very brilliantly with the production of white fumes.

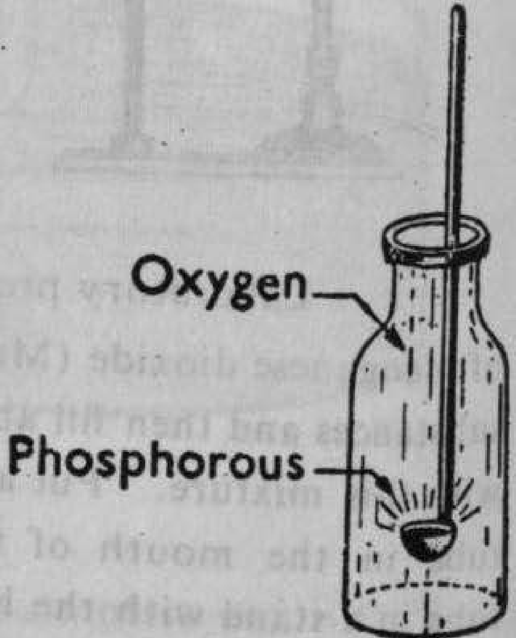


Fig. 8.3
Burning of phosphorous in oxygen gas.

When the phosphorous is burnt up, put some water in the bottle. The white smoke will easily dissolve in water. Now put a piece of blue litmus in this bottle. You will find that the colour of the litmus changes to red.

3. Repeat this experiment with sulphur. Sulphur powder will burn in oxygen, but burning sulphur will flare up in oxygen. If you add blue litmus solution in the bottle in which sulphur has burnt, it will turn red.

4. Burn one end of magnesium ribbon by heating it in a flame of a spirit lamp. Immediately bring this burning magnesium in an oxygen bottle. You will find that magnesium burns in oxygen with dazzling light, and a white powder will be formed. Dissolve this white powder in water and test the solution with red litmus. Red litmus will turn blue.

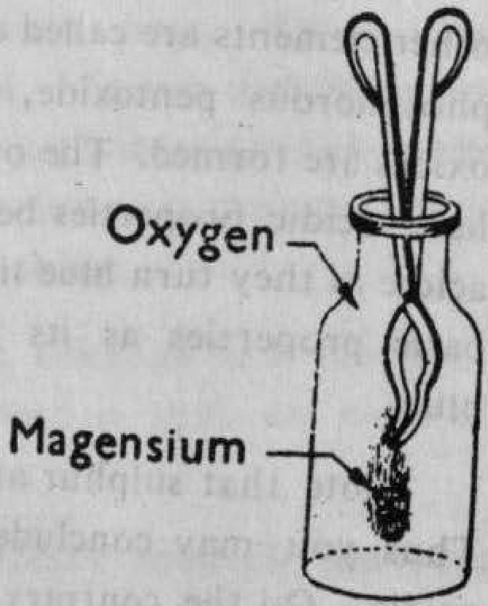


Fig. 8.4
Burning of magnesium in oxygen.

Oxides

In the above experiments you have noted that certain elements burn in oxygen to form compounds which either turn blue litmus red or red litmus blue. The chemical combination of an element with oxygen is called *oxidation* of that element. The chemical reaction of phosphorous, sulphur and magnesium can be represented as under :

(i) Phosphorous + Oxygen ——→ Phosphorous pentoxide.
or $4P + 5O_2 \longrightarrow 2\,P_2O_5$

(ii) Sulphur + Oxygen ——→ Sulphur dioxide
or $S + O_2 \longrightarrow SO_2$

(iii) Magnesium + Oxygen ——→ Magnesium oxide.
or $2\,Mg + O_2 \longrightarrow 2MgO$

Compounds formed by the combination of oxygen with other elements are called *oxides*. In the above experiments phosphorous pentoxide, sulphur dioxide and magnesium oxides are formed. The oxides of phosphorous and sulphur have acidic properties because their solutions in water are acidic as they turn blue litmus red. Magnesium oxide has basic properties as its solution in water turns red litmus blue.

Note that sulphur and phosphorous are non-metals. Thus you may conclude that the oxides of non-metals are acidic. On the contrary magnesium is a metal and its oxide is basic. Thus you may conclude that the oxides of metals are basic.

Water is also an oxide. It is an oxide of hydrogen. But it is neither acidic nor basic. It is a neutral oxide. Those oxides, which show neither acidic properties nor basic properties are called *neutral oxides*.

Uses of Oxygen.

While studying the properties of oxygen you have observed that when an oxidation reaction is very fast, lot of heat is evolved and flame is produced. But some times this oxidation reaction is not very fast but is rather slow. In such cases heat is invariably evolved but without a flame. When we breath in air, the oxygen of the air is absorbed in the blood in our lungs. The blood then carries this oxygen to every part of our body. It also reaches inside the body cells. In the body cells oxygen oxidizes the carbon compounds present there and generates heat. This is the heat which keeps our bodies warm. Carbon dioxide which is produced in this oxidation reaction is carried back to the lungs by the blood stream. In lungs carbon dioxide is exhaled out by the process of breathing.

All plants and animals breath although their modes of breathing may be different. Oxygen is thus an essential thing for our lives.

Those patients who cannot breath properly are kept in plastic tents in which pure oxygen or air mixed with more oxygen is supplied. This is done so that even if the patient breathes in very little air, he should still get enough oxygen in his lungs. All hospitals keep oxygen cylinders for their patients.

Rockets, aeroplanes, railway engines, cars etc., all utilize the energy produced in the chemical reaction of burning some fuel with oxygen. The heat of the oxidation reaction in these devices is converted into mechanical energy. It is this energy of the chemical reaction of oxidation that enables them to move.

If acetylene is mixed with oxygen and is burnt, a very hot flame is produced. The temperature of this flame may go up to 3500°C. The temperature is enough to melt most of the metals. That is why oxyacetylene flame is used for welding and cutting.

Hydrogen

Hydrogen is the lightest of all elements and its atom is the simplest of all. others. Like oxygen, hydrogen is also essential for life. Water, meat, cereals, vegetables and all other food stuffs contain hydrogen. Although its amount in the atmosphere of our earth is very little but sun and other stars still have very large amounts of hydrogen in their atmosphere.

Preparation of Hydrogen

As water (H_2O) is a compound of hydrogen and oxygen, we can get hydrogen from water. Hydrogen is produced when an electric current is passed through water. Pure water is a poor conductor of electricity. You can make water a conductor by mixing some acid (Sulphuric acid or hydrochloric acid), in it. When an electric current is passed through acidulated water, hydrogen is produced at the negative electrode. At the same time oxygen is produced at the positive electrode.

Experiment :

Fill two third of a trough with water. Add a test tube full of sulphuric acid in this water. Thoroughly stir the mixture. Connect the terminals of a 6 volt battery with copper wires. Solder Platinum foils on the other ends of the wires. Bring these ends of wires with platinum foil in the trough of water. Fill two test tubes with the same water and invert them in the trough over the platinum foils as shown in Fig. 8.5. On passing the electric current you will observe oxygen and hydrogen gases forming on the positive and negative electrodes of platinum foils. The bubbles of the gases will collect on the top of the tubes by displacing water downward. The volume of the gas formed on the negative electrode will be double than the volume of the gas that collects on the positive electrode i.e., the volume of hydrogen will be double than that of oxygen.

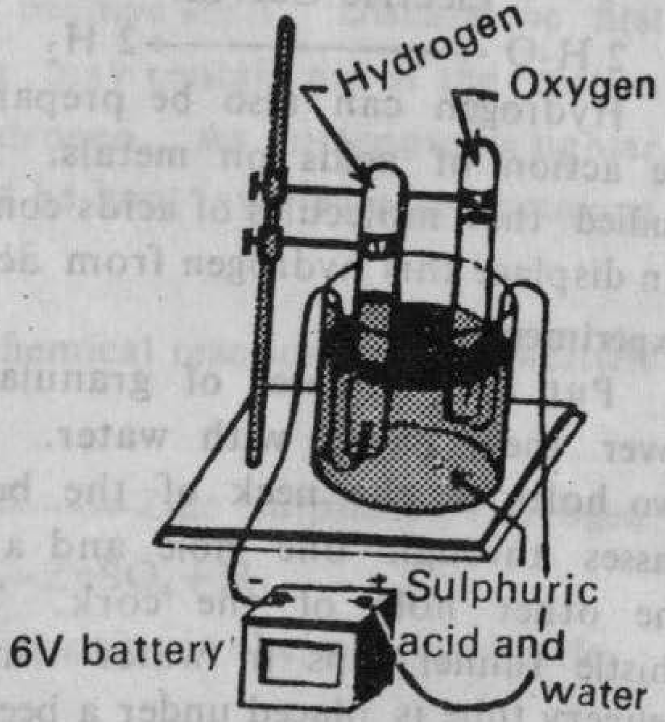


Fig.8.5
Preparation of hydrogen from water.

The breaking up or decomposition of water by the passage of electric current is called *electrolysis*. We can write the equation of the reaction as under.

$$\text{Water} \xrightarrow{\text{Electric Current}} \text{Hydrogen} + \text{Oxygen}$$

or $$2\,H_2O \xrightarrow{\text{Electric Current}} 2\,H_2 \quad + O_2$$

Hydrogen can also be prepared in the laboratory by the action of acids on metals. In chapter 7 you have studied that molecules of acids contain hydrogen. Metals can displace this hydrogen from acids.

Experiment:

Put a few pieces of granulated zinc in a bottle and cover these pieces with water. Now put a cork with two holes in the neck of the bottle. A thistle funnel passes through one hole and a delivery tube through the other hole of the cork. The lower end of the thistle funnel dips in water while the other end of the delivery tube is placed under a beehive shelf in a trough of water as shown in Fig. 8.6.

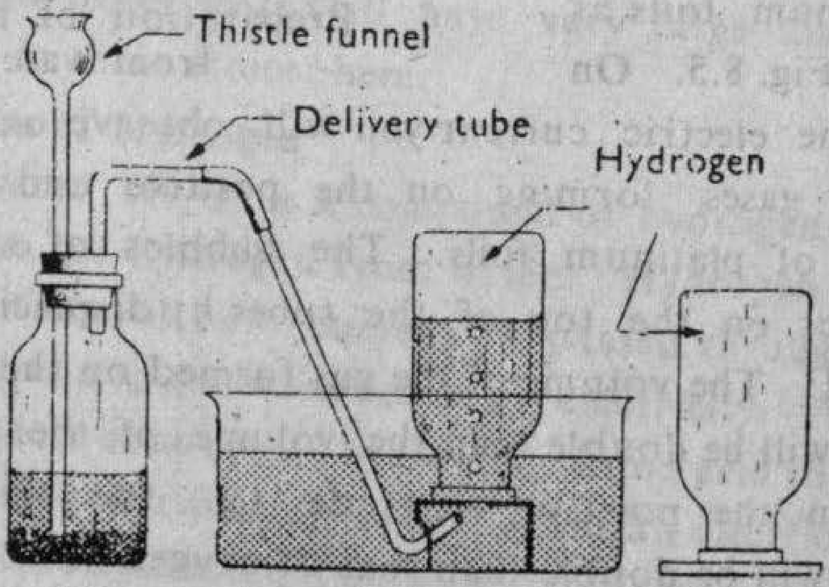


Fig. 8.6
Preparation of Hydrogen

Now add sulphuric acid in the thistle funnel. A chemical reaction starts and hydrogen gas comes out through water. Fill several bottles of hydrogen by inverting water filled bottles on the beehive shelf. Discard the first bottle of hydrogen as it may contain air of the reaction bottle driven out by hydrogen. As hydrogen is lighter than air, the bottles should be kept inverted after removing them from the beehive shelf.

The equation of this chemical reaction may be written as under.

Zinc + Sulphuric acid ——→ Zinc sulphate + hydrogen

or $Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2$

Zinc sulphate thus formed remains in the reaction bottle.

Properties of Hydrogen :

Hydrogen gas is lighter than air. This is because the molecules of hydrogen (H_2) are lighter than all other molecules. These molecules are also the smallest molecules. When you fill a rubber balloon with hydrogen and keep it for some time you will observe that much of the gas has escaped although the mouth of the balloon was tightly closed. This is because the molecules of hydrogen being very small, can pass through the small holes in the stretched membrane of the balloon. Molecules of other gases being larger than these holes, will mostly stay in the balloon.

Like air, hydrogen also has neither any taste nor any smell.

Lift the gas filled bottle carefully and keeping the neck of the bottle downward, remove the lid and take a burning match stick inside the bottle. You will observe that the gas burns quietly but the match stick is extinguished. If the gas contains some air, then it will explode when burning match stick is introduced inside the gas bottle.

The burning of hydrogen in oxygen is a chemical reaction. In this reaction water vapours are formed. The equation of this reaction is as under.

$$\text{Hydrogen} + \text{Oxygen} \longrightarrow \text{Water}$$

or $$2H_2 + O_2 \longrightarrow 2H_2O$$

Test the gas with blue and red litmus papers. There will be no change in colour. What do you conclude from this observation ?

Uses of Hydrogen

Hydrogen is a very useful element. Many industries depend on hydrogen and its compounds. For example, hydrogen combines with nitrogen in the presence of a catalyst to form a compound called ammonia. The formation of ammonia is illustrated in Fig. 8.7. The chemical reaction is represented by the equation.

$$3H_2 + N_2 \longrightarrow 2NH_3$$

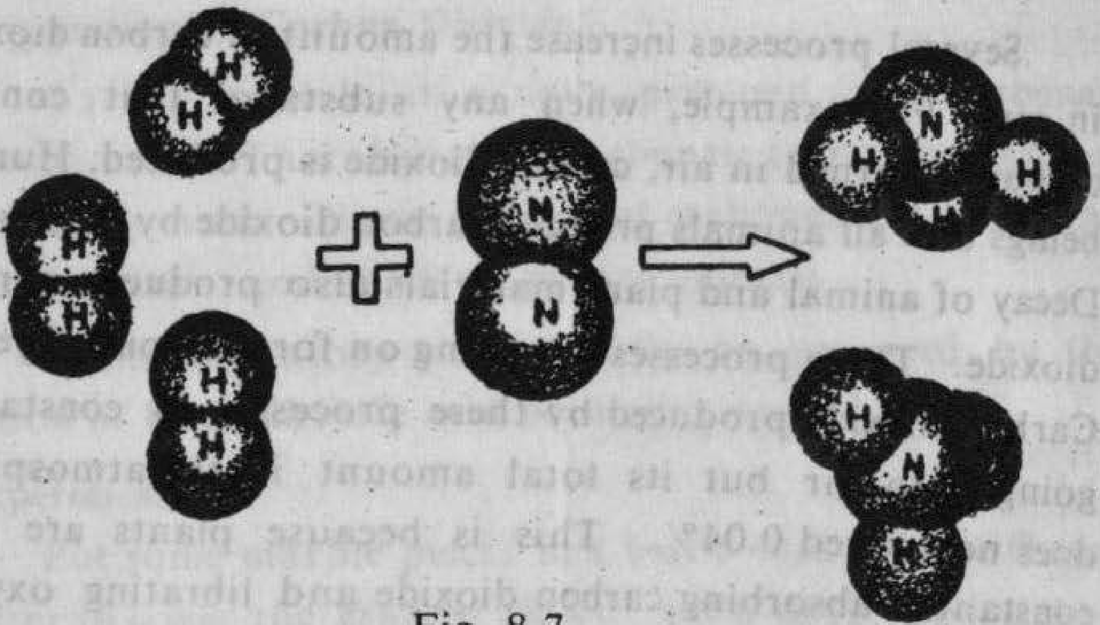


Fig. 8.7

Ammonia is a gas and is used for the manufacture of chemical fertilizer ammonium sulphate $(NH_4)_2SO_4$, washing soda, nitric acid and explosives.

In our country a large quantity of hydrogen is utilized in the preparation of vegetable ghee. In order to prepare vegetable ghee, vegetable oils are first refined to remove colouring matter and bad smelling compounds. Hydrogen is then passed through this purified vegetable oil in the presence of a catalytic agent. Vegetable oil and hydrogen react together to form vegetable ghee.

Liquid hydrogen is used in space rockets as fuel.

Carbon Dioxide

Although the amount of carbon dioxide in the air is only 0.03 or 0.04% but this small percentage is very essential for supporting life on earth. The percentage of carbon dioxide varies a little bit but the total amount does not exceed 0.04%.

Several processes increase the amount of carbon dioxide in air. For example, when any substance that contain carbon is burned in air, carbon dioxide is produced. Human beings and all animals produce carbon dioxide by breathing. Decay of animal and plant materials also produces carbon dioxide. These processes are going on for millions of years. Carbon dioxide produced by these processes is constantly going into air but its total amount in the atmosphere does not exceed 0.04%. This is because plants are also constantly absorbing carbon dioxide and librating oxygen into the atmosphere. Plants use carbon dioxide as their food. From this carbon dioxide they use carbon to grow and form leaves, stems and flowers etc. Oxygen is left behind which goes into the atmosphere. This process is going on in plants in the presence of sun light, and is called *photosynthesis*. Thus a cycle is set up. Breathing burning and decaying produce carbon dioxide and photosynthesis in plants converts this carbon dioxide into oxygen.

Carbon dioxide is a very useful material with which our food is manufatured by plants. We get our food from plants or from animals that eat plants. Our clothing is also made from plant materials like cotton, jute, rubber etc., or by animals that eat plants. For example, we get wool, silk, leather from animals that eat plants. Wood or coal that we burn for cooking or keeping us warm are also plant materials. Thus carbon dioxide is a useful raw material that God has given us for sustaining our lives and making us comfortable.

Preparation of Carbon Dioxide.

Carbon dioxide is usually prepared from carbonate compounds. There are many carbonate compounds present in earth's crust. Some important carbonates include lime stone, marble, and shells of marine animals.

In the laboratory it can easily be prepared by the action of hydrochloric acid on marble pieces.

Experiment.

Put some marble pieces in a bottle and add sufficient water to cover the marble pieces. Fit a cork having two holes in the neck of the bottle. Through one hole pass a thistle funnel and through the other a delivery tube bent twice at right angles as shown in Fig. 8.8. Put a bottle or a gas jar under the other end of the delivery tube.

Now add hydrochloric acid through the thistle funnel. The acid will react with marble pieces and the carbon dioxide bubbles will be seen coming out of the liquid. In order to see whether the collecting bottle has been filled with the gas or not, bring a burning match stick at the mouth of the bottle. If the burning match stick is extin-

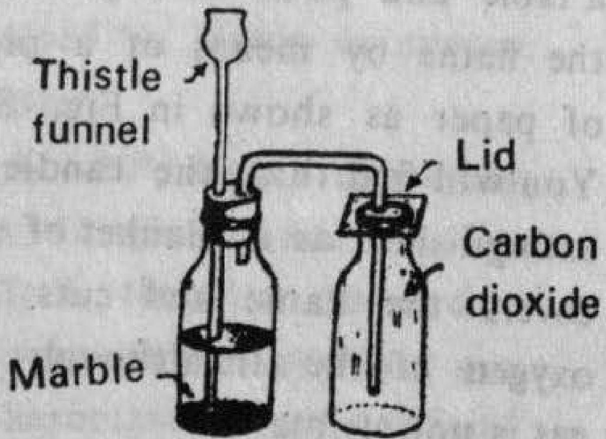


Fig. 8.8
Preparation of Carbon dioxide.

guished, it will be an indication that the collecting bottle has been filled with the gas. The chemical reaction of the production of carbon dioxide can be represented as under.

Calcium carbonate + hydrochloric acid
$\longrightarrow$ Calcium chloride + Carbon dioxide + water

or $CaCO_3 + 2HCl \longrightarrow Ca\,Cl_2 + CO_2 + H_2O$.

Properties of Carbon dioxide.

Carbon dioxide gas is heavier than air. It can, therefore, be transferred from one vessel to the other like a liquid. Carbon dioxide being heavier will displace air from any cantainer in which it is poured. It is due to this property that deep wells and caves are usually found filled with this gas.

Experiment.

Prepare carbon dioxide in a bottle by adding hydrocholoric acid to marble pieces. Place a burning candle on a table and pour this gas over the flame by means of a piece of paper as shown in Fig. 8.9. You will find that the candle is extinguished as a blanket of gas covers the flame and cuts off oxygen of the air, although the gas is not visible.

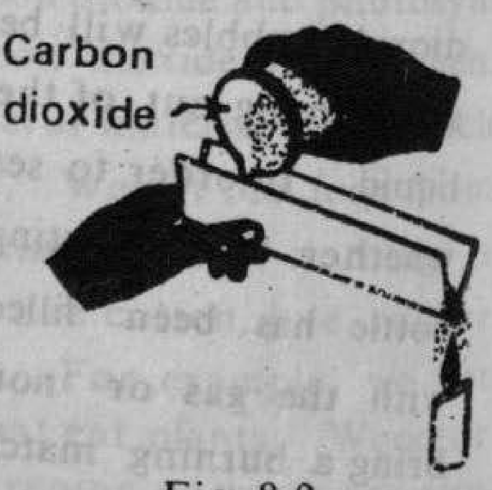


Fig. 8.9
Carbon dioxide being heavier, can be poured like water.

Add a few drops of blue litmus solution in a bottle filled with carbon dioxide. The blue litmus will turn red. Thus carbon dioxide is an acidic oxide.

Prepare carbon dioxide in a test tube and in another test tube take a few cubic centimeters of lime water (a solution of calcium hydroxide in water). Pass the gas through lime water by means of a delivery tube fitted with a cork in the mouth of the tube in which the gas is being prepared. You will find that the lime water turns milky. On passing more gas the milkiness disappears.

Carbon dioxide reacts with lime or calcium hydroxide to form calcium carbonate which is an insoluble white substance. This compound produces milkiness. By passing more carbon dioxide, however, calcium carbonate is changed into calcium bicarbonate which is soluble in water and so the milkiness disappears. These experiments are used to test the presence of carbon dioxide.

Uses of Carbon dioxide.

1. Carbon dioxide is dissolved in water or syrups under pressure to prepare soda water.

2. When this gas is cooled to —80°, it gets converted into a solid state. Solid carbon dioxide changes to the gaseous state without melting. It is, therefore, called dry ice. Dry ice is used as refrigerant. Dry ice crystals are sprinkled on clouds by means of aeroplanes to get artificial rain.

3. This gas is used in sugar industry for the refining of the juice.

4. Carbon dioxide is also used for extinguishing fire. A fire extinguisher does not store carbon dioxide. Instead it contain sodium carbonate ($Na_2 CO_3$) and an acid in separate compartments. When carbon dioxide is required for extinguishing fire, these two chemicals are allowed to mix and react to produce carbon dioxide.

Questions

1. You are given three gas cylinders. One of the cylinders contains oxygen, the other carbon dioxide and the third is filled with air. How will you find out which cylinder contains which gas !
2. How will you prepare oxygen in the laboratory ? Write the chemical equation of the reaction. Describe three chemical properties of oxygen.
3. Give four uses of oxygen.
4. What elements are present in water ? Give the chemical formula of water. How many atoms are present in a molecule of water ? Draw a model of water molecule.
5. How can you prepare oxygen from water ? Write equation of the chemical reaction ?
6. Describe an experiment for the preparation of hydrogen. What precautions would you take for keeping hydrogen in a bottle ?
7. What compound is formed when hydrogen burns in air ?

8. Describe two uses of hydrogen.
9. What elements are present in carbon dioxide? How will you prepare carbon dioxide in the laboratory?
10. Describe the carbon dioxide cycle in nature. Why does the amount of carbon dioxide does not increase in the atmosphere?
11. Complete the following sentences :
    (i) Carbon dioxide turns lime water——.
    (ii) A burning candle will extinguish in a cylinder of——gas.
    (iii) ——is the lightest gas.
    (iv) When oxygen combines with an element, the reaction is called——.
12. What is dry ice? Why is it called dry ice? Give two uses of dry ice.
13. Why do we say the burning and breathing are similar reactions?
14. What are oxides? Give four names of oxides and write their formulae. An oxide shows no change in colour with blue litmus, but it turns red litmus blue. Is it an acidic, basic or a neutral oxide? Do you think it is an oxide of a metal or a non-metal?

9

Light

9.1 The Nature of Light

Light is a form of energy. Any object which emits light is called a source of light. Sun is the biggest source of light for us. Man-made things, which give out light are called artificial sources of light. Oil lamps, candles, lanterns, electric bulbs and tubes are artificial sources.

Scientists have found that light travels in the form of waves. These waves can pass through all transparent materials, such as air, vacuum, water, glass, etc. We cannot directly see light as waves, but a number of experiments on the nature of light make us believe that light does move as waves.

There are some other experiments which show that light also moves as a stream of particles, called the *photons*. Again it is not possible for any one to see the photons but scientists have found some properties of light which show that photons do exist.

In short, we can describe light as a form of energy which has the nature of waves under some conditions and of particles under some other conditions. It travels in a straight line as long as it is in the same medium like air, glass etc. After knowing about physical nature of light, we seldom use the words, a wave of light, or 'a stream of photons' for it. Usually we say a *ray of light*. Rays of light are drawn as straight lines along which the light waves or the photons are moving.

9.2 Speed of light

Light travels very fast. For a long time man used to think that no time was taken by light to travel from one place to another. An Italian scientist, Galileo tried to measure the speed of light but he did not succeed. In the 17th century another scientist, Roemer, first measured the speed of light. Then in 1849, Fizeau of France, performed an experiment to find the speed of light. After Fizeau other scientists performed better experiments for this purpose. From these experiments the speed of light in vacuum has been found to be 10×3^5 Kilometers per second. Light travels with a different speed in different transparent media. Its speed is less in denser media. The speed of light in water is 223698 Kilometers per second and in glass it is 199558 Kilometers per second.

The speed of light in air is not too different from that in vacuum because air is not so dense. The speed of light in air is also taken as 11×3^5 Kilometers per second.

9.3 Refraction of light

We have already explained that light travels in straight lines but it will only be true as long as it remains in the same medium. If a ray of light enters from one medium into another, say from air to water, it changes its direction. This is called the *refraction of light*. The direction of light is changed because the speed changes when light moves from one medium into another.

The principle of refraction is explained in Fig. 9.1. AB is a ray of light moving in air. It enters water at B. This point is called the *point of incidence*. If the ray meets the surface of water obliquely, its path in water is bent and it moves along BC.

A line NB is drawn, perpendicular to the surface of water and it is called *normal*. In air the ray makes an angle ABN with the normal. It is called the *angle of*

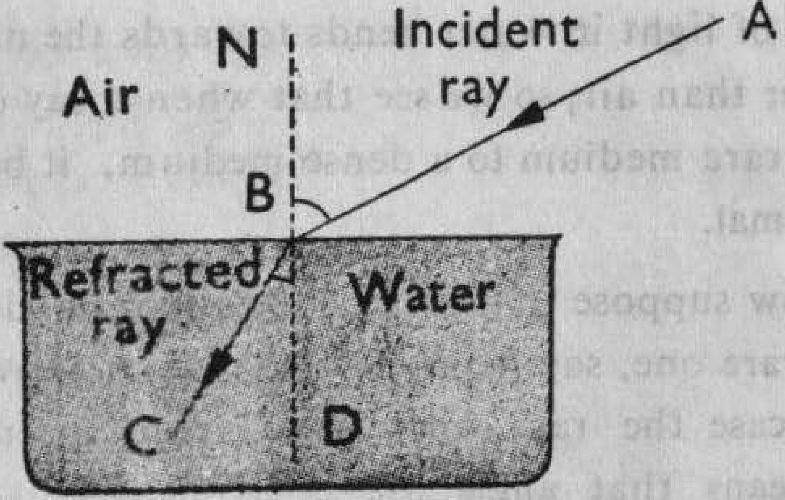

N
Air
Incident
ray
A
B
Refracted
ray
Water
C
D

Fig. 9.1

incidence. In water the ray makes an angle CBM with the normal, and it is called the *angle of refraction.* Due to refraction, the direction of light is so changed that angle of refaction is less than angle of incidence. In other words

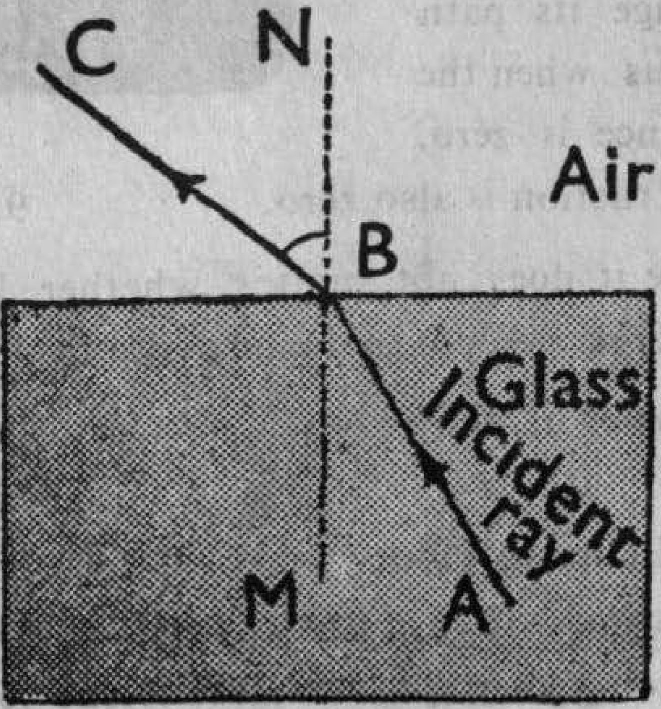
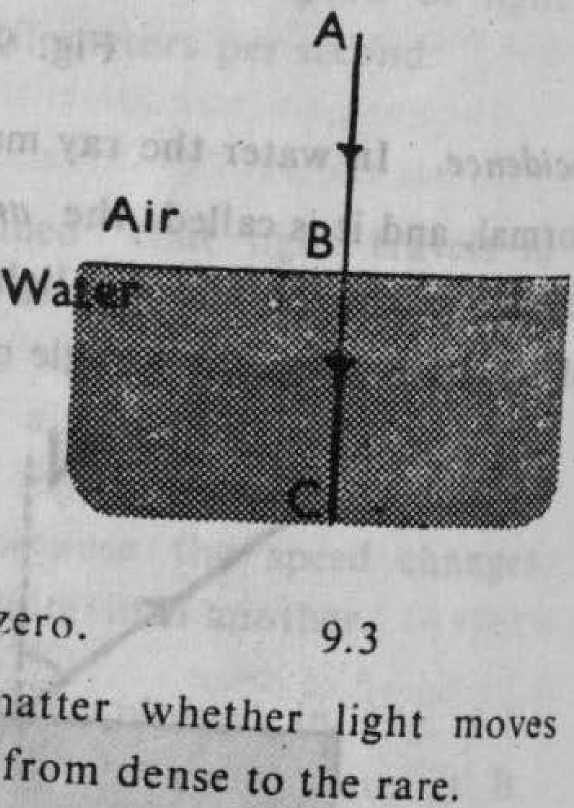

C
N
Air
B
Glass
Incident
ray
M
A

Fig. 9.2

the ray of light in water bends towards the normal. Water is denser than air, so we see that when a ray of light moves from a rare medium to a dense medium, it bends towards the normal.

Now suppose that a ray comes from a dense medium into a rare one, say from glass to air, as shown in Fig. 9.2 In this case the ray bends away from the normal which also means that angle of refraction is greater than angle of incidence.

If the ray of light is not inclined to the common surface of the two media but crosses it vertically, it does not change its path (Fig 9.3). Thus when the angle of incidence is zero, the angle of refraction is also zero.



9.3

In this case it does not matter whether light moves from rare to dense medium or from dense to the rare.

Practical Examples of Refraction

Experiment

Place a coin in an empty cup. Adjust your eye at such a position that you cannot see the coin. Without displacing your eye, ask your friend to fill the cup with water. When the cup is filled with water, you will be able to see the coin. It will appear as if the coin, as well as the bottom of the cup, has been raised up (Fig. 9.4).

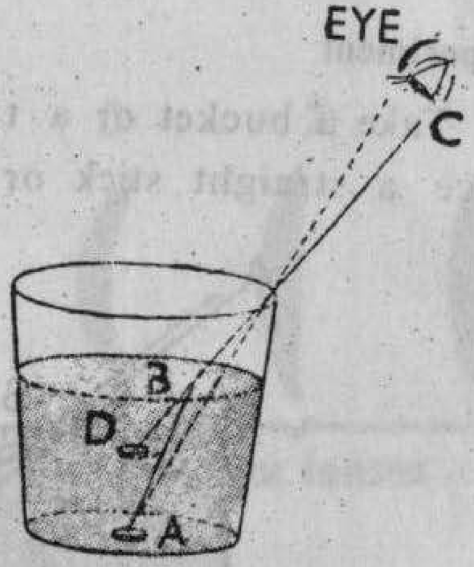


Fig. 9.4

Without water in the cup you were unable to see the coin because no ray of light from it could reach you. The edge of the cup was causing an obstruction. When water is poured, a ray of light travelling along AB in water is bent away from the normal as it comes out in air. It moves along BC and now it can reach the eye. The ray appears to be coming from a point D. Thus you see the coin raised to position D. Also the depth of the cup appears to be less.

We see from the above experiment that if we look in a tank, which is full of water, its bottom seems to be raised Its apparent depth is less than the real.depth. If the depth of water in the tank is actually 1.2 meters, it appears to be .9 meters due to refraction.

In some parts of the world fishermen hunt fish with spears. Due to refraction a fish appears to be a little higher than its real position. If the spear is aimed at the apparent position of the fish, it will miss the target. These people hit the fish correctly by aiming the spear a little lower than where the fish appears to be.

Experiment

Take a bucket or a tub containing enough water. Place a straight stick or a pencil obliquely in water.

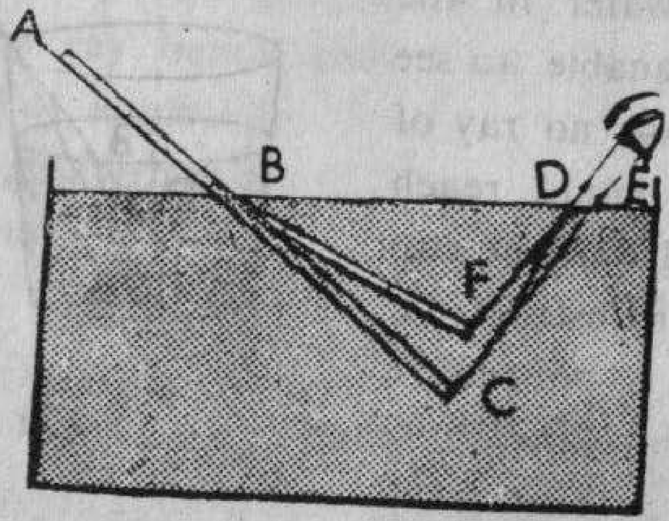


Fig. 9.5

A part of the stick should be in water and the rest of it outside. Now look at the stick carefully. Its part in water appears to be bent as shown in Fig. 9.5.

Let ABC be the stick and its part BC be in water. CD is a ray of light coming from C. When it comes out of water, it bends along DE, and the eye sees as if the ray was coming from a point F. Therefore, the end C of the stick appears to be at F and the part BC of the stick seems to be bent upward as BF.

9.4 Lenses

A lens is a flat piece of a transparent material, usually glass. It is so made that at least one of its faces is spherical. Lenses can be of many types as shown in Fig.

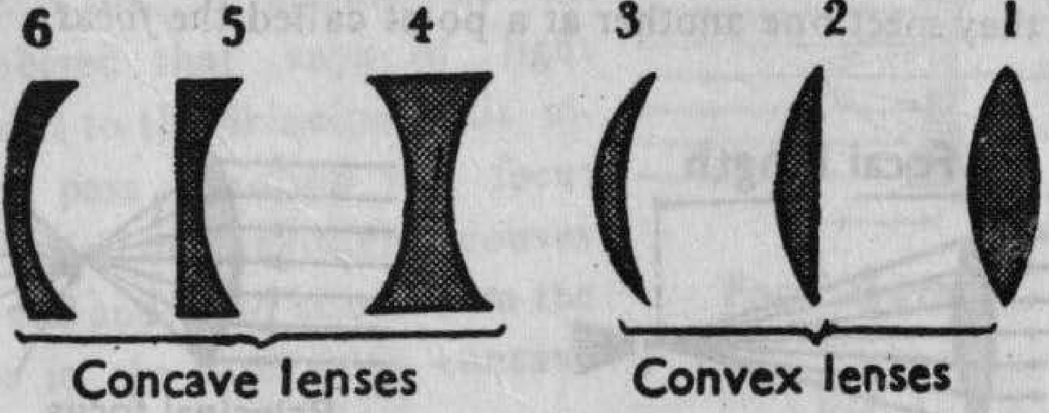


Fig 9.6.

9.6. Lenses from No. 1 to No. 3 in this figure are thicker in the middle than at the edges. They are called *convex lenses*. Those from Nos. 4 to 6 are thinner in the middle. They are *concave lenses*.

Hold a convex lens facing the sun. If you place it at a suitable distance above a piece of paper, you will see a little spot of light. It will be very bright and hot. If a match stick is placed with its head in the spot, it will catch fire quickly (Fig. 9.7). For this reason a convex lens is sometimes called a burning glass. What happens is that the heat and light rays passing

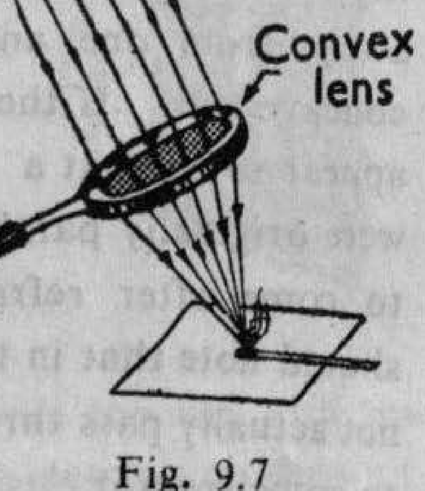


Fig. 9.7

through the convex lens bend towards one another and collect at a point.

In Fig. 9.8 parallel rays pass through a convex lens and they meet one another at a point called the *focus*. The distance of the focus from the lens is called the *focal length* of the lens. Thicker lenses have shorter focal lengths The lens in Fig. 9.9 for example, has a shorter focal length than the one in Fig. 9.8.

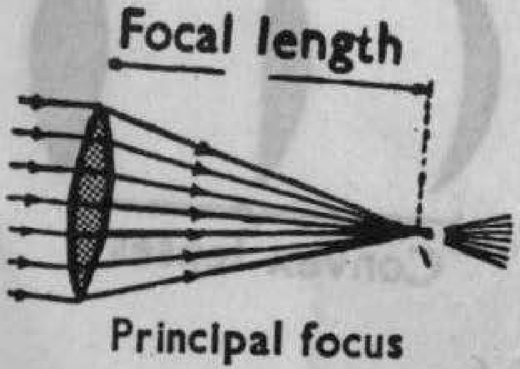


Fig. 9.8

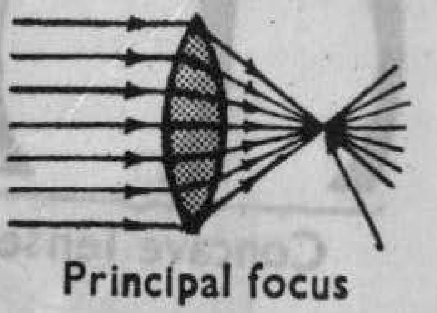


Fig. 9.9

Concave lenses have the property of spreading the light rays. This is shown in Fig. 9.10. In this case the rays move aways from one another after they pass through the concave lens. If these rays are produced backward, they appear to meet at a point behind the lens. If the rays were originally parallel, the point from which they appear to come after refraction is the focus of the lens. You should note that in the case of a concave lens the rays do not actually pass through the focus, but they only appear to come from it.

A lens has two foci, one on each side. The straight line joining the two foci is called the *principal axis* of the lens. (Fig. 9.10). It should be remembered that rays of light parallel to the principal axis always pass through the focus after refraction through a convex lens and appear to come from the focus in the case of a concave lens.

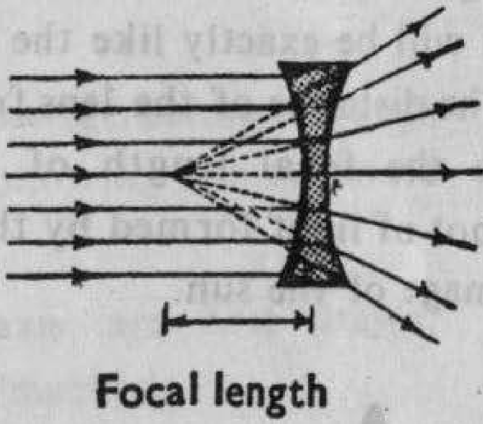


Fig. 9.10

9.5 Formation of Image by a Convex Lens

You can perform an interesting experiment in a room with the help of convex lens. Bring the lens near a wall opposite to which there may be window. Outside the window there should be objects like trees, buildings, etc.

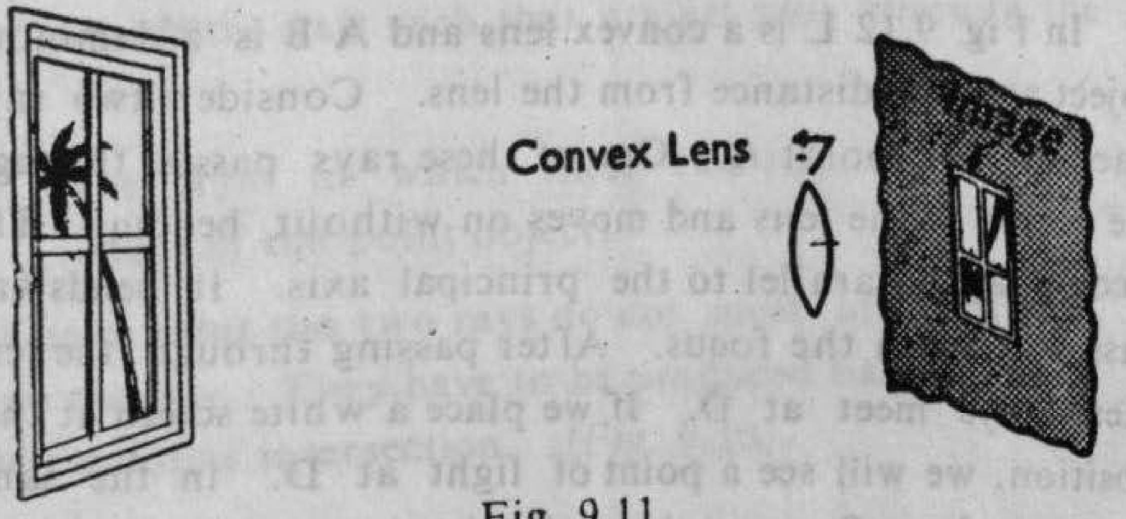


Fig. 9.11

Now adjust the distance of the lens from the wall, till you see a clear picture or image of the outside view on the wall.

This image will be inverted , up side down as well as from right to left. Also it will be of a smaller size, but otherwise it will be exactly like the original view with all its colours. The distance of the lens from the wall will be almost equal to the focal length of the lens. In Fig. 9.8 the little spot of light formed by the convex lens is actually a tiny image of the sun.

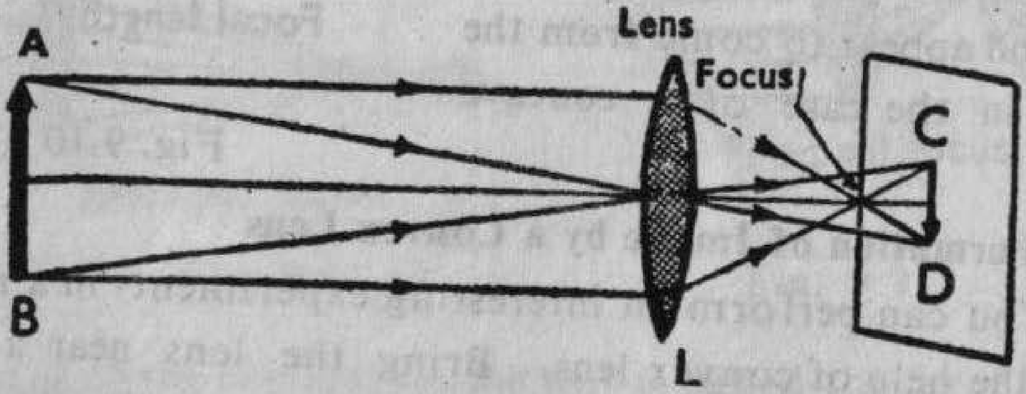


Fig. 9.12

In Fig. 9.12 L is a convex lens and A B is a luminous object at some distance from the lens. Consider two rays starting from point A. One of these rays passes through the centre of the lens and moves on without bending. The second ray is parallel to the principal axis. It bends and passes through the focus. After passing through the lens these rays meet at D. If we place a white screen at that position, we will see a point of light at D. In the same way rays from B pass through the lens and meet at C. Thus the image of A is formed at D and image of B is at C. The image of points between A and B will lie between

C and D. An inverted image CD of the object AB is thus formed on the screen. This image is said to be *real* because it can be obtained on a screen.

In drawing diagrams of rays to show refraction through a lens and formation of images, the following points should be noted.

1. The lens and its principal axis are first drawn. The foci of the lens are also marked.
2. Two rays are taken from a point on the object. One of these should go towards the centre of the lens and the other should be parallel to the principal axis.
3. The ray passing through the centre of the lens moves straight without bending.
4. The ray parallel to the principal axis bends towards the axis such that it must pass through the focus.
5. The point at which these two rays meet in the image of the point object.

In some cases the two rays do not meet after passing through the lens. They have to be produced backwards to get their point of intersection. (Fig. 9.10).

Experiment

Mount a convex lens on a stand and place it on a table. Also place a lighted candle on one side and a screen on the

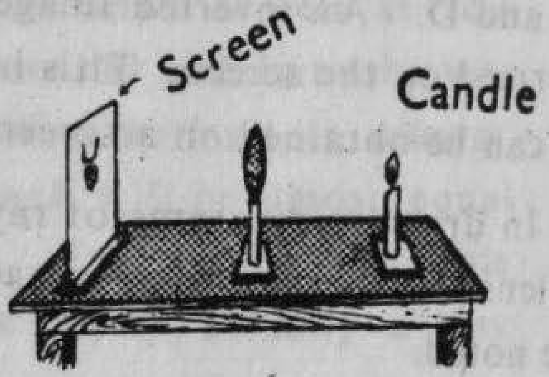


Fig. 9.13

other side of the lens. The three things should be at the same height and should be in one line. The distance between the candle and the lens should be at least twice as much as the focal length of the lens. Move the screen to and fro till you get a sharp image of the candle flame, (Fig. 9.13). Note the distance of the screen from the lens.

Now move the candle a little away from the lens. To get its image again you will have to move the screen closer to the lens. The image will now be smaller in size. If the candle is taken farther, its image will come nearer and nearer to the focus.

If, on the other hand, the candle is brought nearer the lens, the screen will have to be moved away from the lens to get the image of the candle. When the distance between the candle and the lens is equal to, or less than the focal length, you will not be able to get the image anywhere. If you remove the screen and look through the lens, you will see an erect image of the candle This type of image is called a *virtual image*. It can be seen but cannot be obtained on a screen. In Fig. 9.15 it has been shown by drawing rays of light how a virtual image is formed.

9.6 Uses of Lenses

(a) Magnifying Glass : Take a convex lens having a focal length of less than a few inches. Place it over a page of a book and look at the words through it. Now move the lens upwards till its distance from the page is a little less than its focal length. The words will appear to be magnified and erect. Thus a convex lens of short focal length can magnify small objects in this simple way. It is, therefore, called a *magnifying glass.* The smaller the focal length the greater will be its ability to magnify. A magnifying glass is very useful to a watch-maker. He puts it near his eye when he wants to examine or repair a watch.

The principle of the magnifying glass is explained in Fig. 9.14. AB is a small object placed near a lens. Two rays from point A of the object are shown passing through the lens. The refracted rays are produced backward to intersect at a point C. So the rays after passing through the lens, appear to come from C. Thus C is the image of

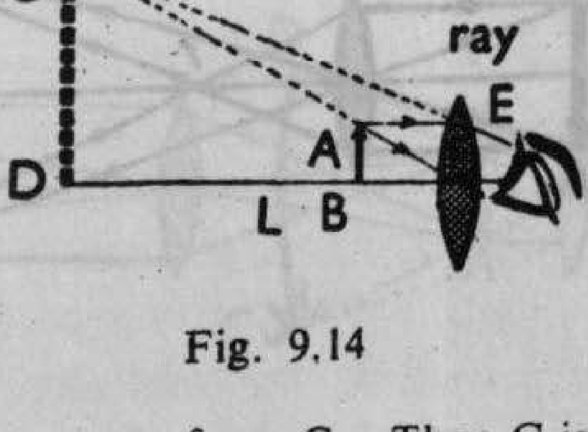


Fig. 9.14

point A of the object. Similarly the images of all the points on the object AB will be formed on CD, a perpendicular from C to the principal axis. Therefore, when we look through the lens, a virtual image CD of the object AB is seen.

(b) The Film and the Slide-Projector : In cinemas we see movie films and advertisement slides on a big screen. The actual picture on the film or the slide is very small. An enlarged image of it is projected on the screen by a machine called the *projector*.

There is a powerful electric bulb just behind the celluloid picture. The light of the bulb illuminates the picture. A convex lens projects its image on the screen (Fig. 9.15). The farther the screen, the bigger is the image. The lens can be moved to and fro to get a sharp image.

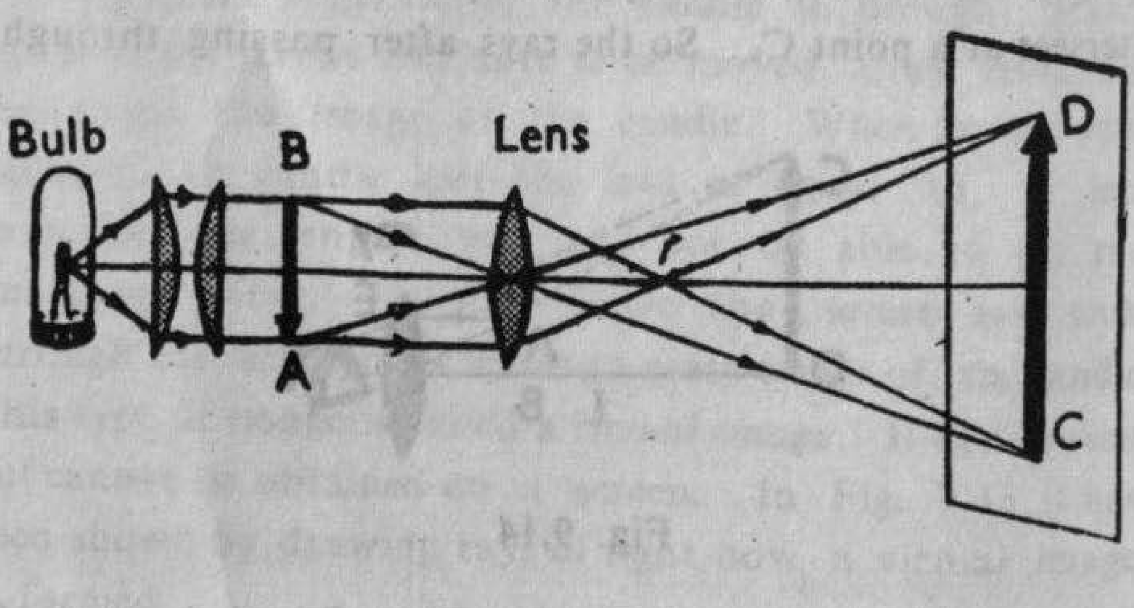


Fig. 9.15

There is another convex lens or a pair of lenses to throw more light on the picture. It concentrates the rays. The picture is placed inverted in the projector so that its image may be erect.

(c) **Telescope :** A simple telescope can be made with two convex lenses, one of long focal length and the other of short focal length. Rays of light from a distant object fall on the lens of longer focal length. They form a real inverted image AB, as shown in Fig. 9.16. The other lens, called the eye-piece, is placed near the image. It can be moved to and fro. This lens works like a magnifying glass. Through in the image AB can be seen as a magnified virtual image CD, which is also inverted. This type of telescope is used for viewing heavenly bodies because there is no difference if these objects are observed inverted.

Telescopes can be so designed as to give erect image. In such a telescope a concave lens of short focal length is used as an eye-piece instead of a convex lens.

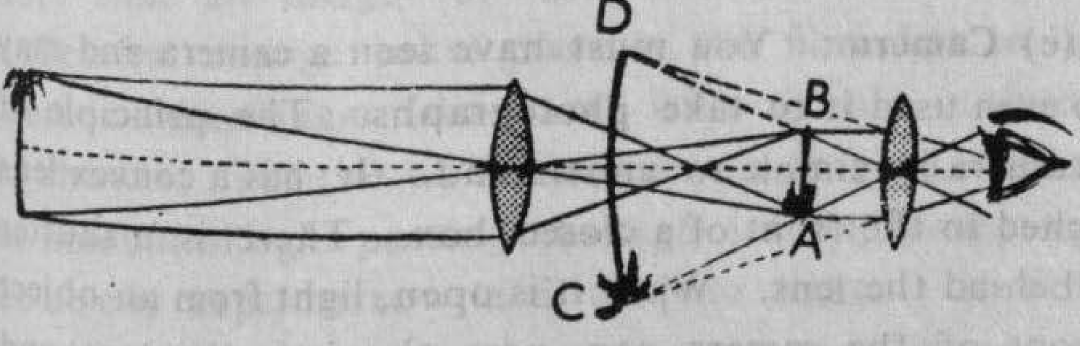


Fig. 9.16

(d) **Microscope**: A microscope is used to magnify objects placed under it. In its simple form it consists of two convex lenses of short focal length. The first lens, near the object, forms its big real image. The second lens, that is the eye-piece, acts like a magnifying glass and magnified image of the object formed by the first lens is seen.

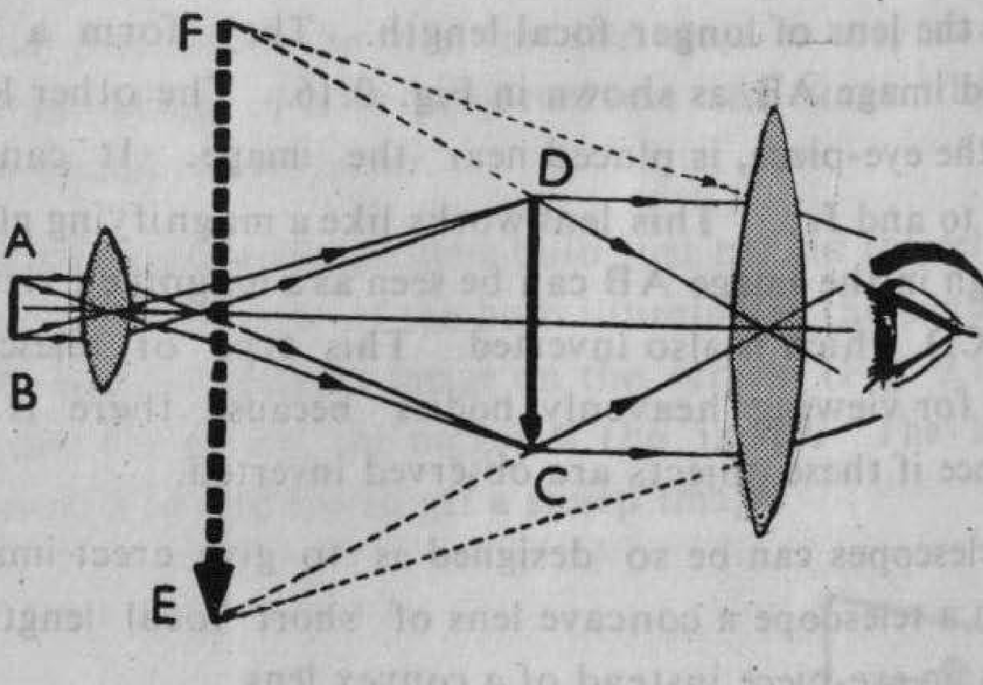


Fig. 9.17

(e) **Camera**: You must have seen a camera and may have even used it to take photographs. The principle of the camera is simple to understand. It has a convex lens attached to the front of a closed box. There is a shutter just behind the lens. When it is open, light from an object in front of the camera can pass through the lens and an image is formed on a film inside the camera.

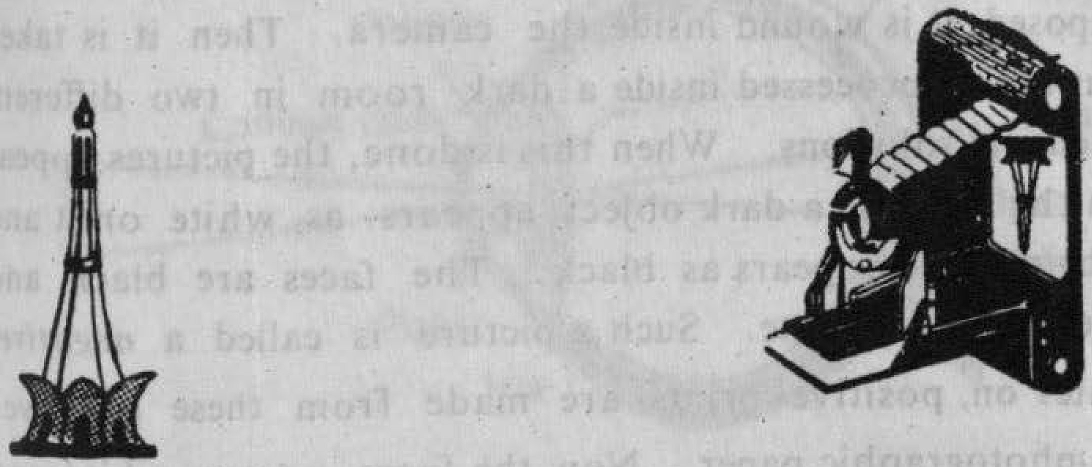


Fig. 9.18

The lens can be moved to and fro. Its position should be correctly adjusted according to the distance of the object so that a sharp image is obtained on the film. This process is called focussing of the camera.

A button is pressed for taking the photograph. The shutter opens for an instant and closes again. During this short time an image of the scene falls on the film. A chemical change takes place in the film due to light There is a diaphragm (dia-fram) with a hole in it near the shutter. The size of the hole can be changed to control the amount of light passing through it. In strong light the hole is kept narrow and in poor light it is wider. This is necessary because the image on the film must be of correct brightness.

Cameras of different types can take 8,12 or 36 pictures on the same strip of film. When the entire film has been exposed, it is wound inside the camera. Then it is taken out and is processed inside a dark room in two different chemical solutions. When this is done, the pictures appear on the film but a dark object appears as white on it and a bright one appears as black. The faces are black and the hair look white. Such a picture is called a *negative.* Later on, positive prints are made from these negatives on photographic paper. Now the faces appear white and hair black as they really are. Positive prints are made in the dark room by a similar process as in the case of the film.

9.7. The eye

The Almighty Allah has given us eyes to see the world around us. The structure of the eye was first studied by the Muslim scientist, Ibn-al-Haisam. The front part of the eye is made of a transparent skin called the *cornea.* Light passes through it into the eye.

Behind the cornea there is a diaphragm like that of a camera.. It is called the *iris* and the hole in it is known as the *pupil.* Muscles attached to it can change the size of the pupil so that a correct amount of light may go inside the eye.

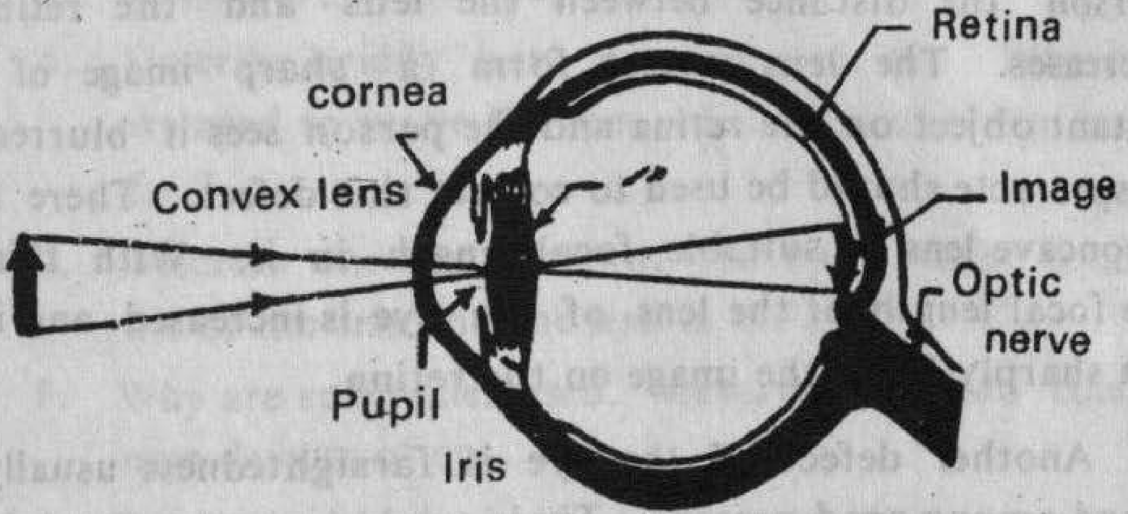


Fig. 9.19

There is a convex lens next to the pupil. It can expand or contract and change its focal length. The lens forms a sharp image of the object to be seen on the back of the eye, called the *retina*. The retina is supplied with a network of very fine and sensitive nerves which are connected to the brain by the *optic nerves*. All details, such as shape, colour motion, etc., of the image formed on the retina are sent to the brain through the optic nerve.

The inverted image formed on the retina is changed into electric impulses or signals in a complicated way. These impulses reach the brain and we feel the presence of the object.

Defects of Eyes

Sometimes people develop a defect in their eyes and they cannot see distant objects clearly. This defect is known as near sightedness. In the eye of a near sighted person the distance between the lens and the retina increases. The lens cannot form a sharp image of a distant object on the retina and the person sees it blurred. A spectacle should be used to correct this defect. There is a concave lens of suitable focal length in it. With this, the focal length of the lens of the eye is increased and it can sharply focus the image on the retina.

Another defect of the eye is farsightedness usually found among aged persons. Their eye-lens cannot properly contract and its focal length cannot become shorter than a certain limit : The result is that nearby objects are not sharply seen by them. They have to use spectacles with convex lenses. A convex lens, when combines with the eye-lens, shortens its focal length to the required limit.

Questions

1. Explain the principle of refraction of light with the help of a diagram.
2. Describe an experiment to illustrate refraction of light.
3. What is the difference between a convex lens and a concave lens ? Draw a diagram to explain what you mean by the focal length of a convex lens ?
4. What is a real image ? Explain how a convex lens forms a real image of an object.
5. Describe the working principle of one of the following :

Projector, Telescope, Microscope.

6. Describe briefly how a camera works. Why do we need to move the lens of the camera to and fro ?
7. Describe the structure of the eye. What is the use of the iris and the lens in the eye ?
8. Why are spectacles used. Describe the two common defects of eye.
9. Fill in the blanks in the following sentences
   (a) Light travels as——under some conditions and as——under some other conditions.
   (b) The speed of light in air is——.
   (c) If a ray of light enters from a——medium into a———medium, it bends towards the normal.
   (d) The depth of water in a 1·2 meters deep tank appears to be——meters.
   (e) The real image formed by a convex lens is——
   (f) The——is a network of sensitive nerves.
   (g) If distant objects appear blurred due to defective sight, a spectacle with——lenses is used.

10

Sound

We come across many types of sounds everyday. The crying of children, chattering of birds, the rustling of leaves of trees by breeze, the noise of automobile engines and wheels etc., are familiar to us. In this chapter we shall study how sound is produced. What is the nature of sound and how does it travel from place to place ? What is its speed ? We shall also discuss the difference between musical sounds and noise and how do we talk and hear.

10.1 The Nature of Sound

Like heat, light and electricity, sound is also a form of energy. When the school bell rings, the sound is produced by the blow of hammer on the brass plate. A flute and whistle produce sound by blowing through them. In order to play on sitar or violin, we have to pluck the wires. In these examples the brass plate of bell, the air in the flute or the strings of violin. all vibrate. This vibration produces sound. We shall now produce sound by some experiments and study this vibratory motion.

Experiment

Take an iron strip about 30cm long. Place the strip on an edge of a table about 22.5cm of the strip projecting outwards. Press firmly by books etc., the part of the strip which is on the table (Fig. 10.1). Now pull the projected end of the strip downwards and leave it. The strip will start vibrating up and down and will produce sound. We can say that the strip produces sound due to vibrations.

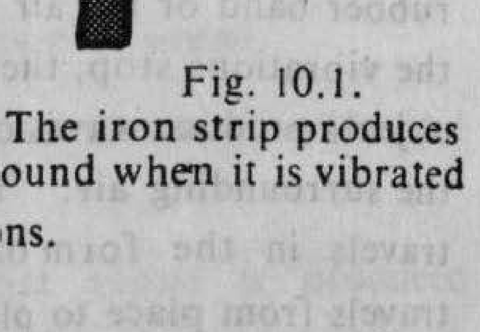


Fig. 10.1.
The iron strip produces sound when it is vibrated

Experiment

Stretch a rubber string by holding its two ends in your hands, Ask your friend to pluck the string at the middle. The rubber will vibrate and will produce sound (Fig. 10.2)

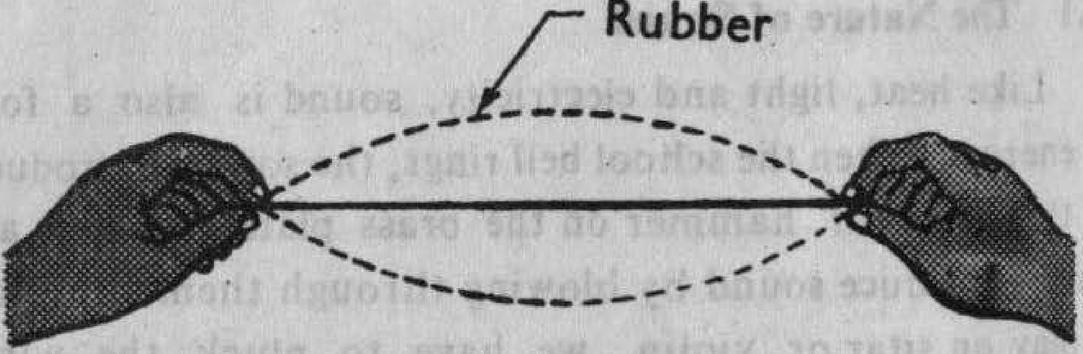


Fig. 10.2

The stretched rubber string produces sound when it is vibrating.

Experiment

Take a bottle or a test tube. Blow at the mouth of the bottle. It will produce sound. If a piece of cork or pith ball is placed in the bottle, the cork will vibrate up and down on blowing. This shows that the air inside the bottle vibrates and produces sound.

In the experiments described above, the iron strip, the rubber band or the air vibrate and produce sound. When the vibrations stop, the sound also stops. The sounding objects produce waves of sound. These waves spread in the surrounding air. You have already studied that light travels in the form of waves. Similarly the sound also travels from place to place in the form of waves. When the string of rubber, the plate of the bell or other objects vibrate about their positions of rest, they produce waves of sound in the surrounding air. For example, when the iron strip moves upwards, it pushes the air above it in the upward direction. This brings the molecules of air close together. At such a place where the molecules of air come close to each other, the air is compressed. A wave of *compression* is produced in the air.

When the strip moves downwards, it leaves more space for the molecules of air above it. Thus the distances between various molecules increase. At such a place the density of air decreases and a wave of *rarefaction* is produced in the air. These waves of compression and rarefaction form the sound waves in air. Many such waves, travelling one behind the other, reach the ear of the listener. In these waves, the molecules themselves do not move bodily from place to place. They only keep vibrating about their main positions of rest. One molecule passes on its motion to the next molecule. In this way the sound waves travel from place to place. On reaching our ears, the sound waves set the ear-drum into vibrations. These vibrations produce the sensation of sound.

10.2 Propagation of Sound in Gases, Liquids and Solids

You have already studied that sound is produced by the vibrations of objects. You have also noted that in air the waves of compression and rarefaction are produced. These waves then move from place to place. Sound travels in air in the form of these waves. Sound also travels through liquids and solids.

Propagation of Sound in Air : If the molecules of air are closer together, the waves produced in it can move from one place to another rapidly. On the other hand if the molecules are far apart from one another, they are unable to pass on the kinetic energy of waves to their neighbours easily. Thus if the pressure of air is low, the waves travel slowly and the speed of sound is less. Thus on the mountains where pressure is low, the sound travels slowly.

In vacuum, there are no molecules and the waves of compression and rarefaction cannot move from place to place. Thus sound cannot travel through vacuum. This may be proved by the following experiment:

Experiment

Take a wide-mouthed flask. Select a cork that fits into its mouth. Fix a hook to the lower end of the cork. From the hook suspend a small bell by means of a thread. Put some water in the flask and boil it. When the water is still boiling in the flask, take it away from flame and close the mouth of the flask with the cork. After sometime, when the flask cools down, the steam inside it condenses to form water drops. The pressure of air above the water thus decreases. Now ring the bell by shaking the flask. The sound of the bell will be extremely feeble. Now open the cork and allow air to enter the flask. On ringing the bell again, louder sound will be heard. In the first case, the pressure of air inside the flask was low and the distances between the molecules were large. The sound of the bell could not easily move through this rare air and feeble sound was heard outside. In the second case the pressure of air inside the flask was greater and the sound reached outside very easily. At normal pressure, the speed of sound in air is 330 meters per second.

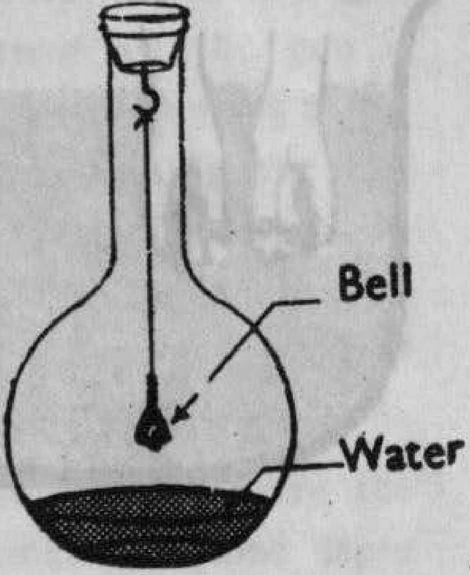


Fig. 10.3

Propagation of Sound in Water : In water and other liquids, the molecules are closer together as compared to air. Therefore sound travels faster in liquids. Thus in water sound travels at a speed of 1440 meters per second, i.e. about 4 times faster than in air.

Experiment

Rub two pieces of stone together under the surface of water in a tub. On pressing your ear close to the side of the tub, you will hear louder sound. If the pieces of stone are rubbed outside in air, the sound will be feeble.

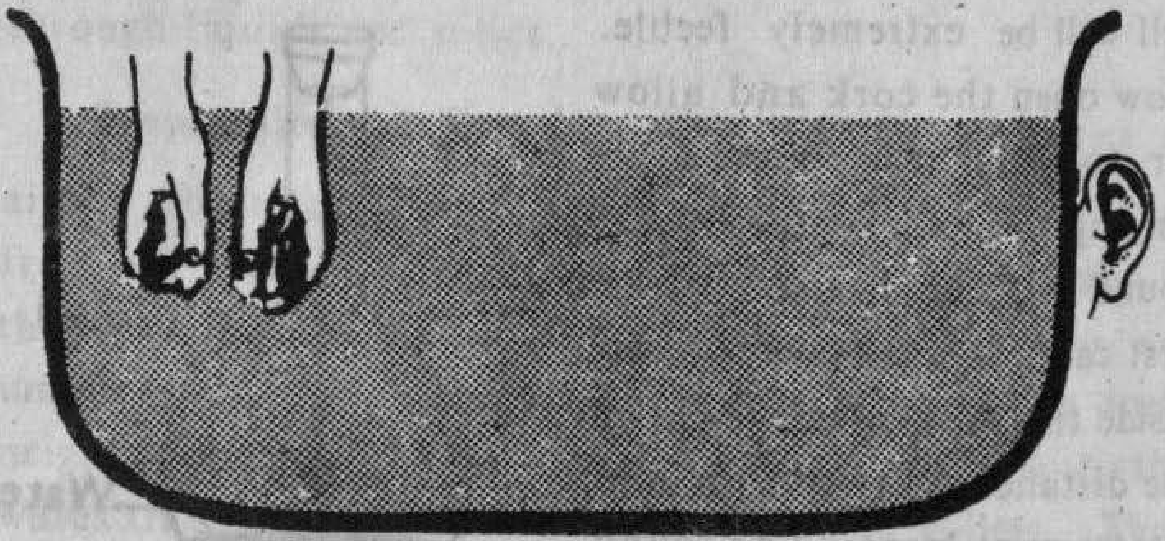


Fig. 10.4

This proves that sound travels faster in water than in air.

Propagation of Sound in Solids : The molecules are more closely packed in solids than in liquids or gases. Thus sound travels faster in solids than in liquids. As an example the speed of sound in wood is 3 kilometers per second which is nine times that of air. The speed of sound in steel is 4.95 kilometers per second.

Experiment

Place a watch near one edge of a table. Now try to listen the sound of the watch first in air and then by placing your ear on the table near the other edge. You will hear louder sound in the second case.

Speed of Sound : From the above discussion we know that the speed of sound is different in air, water and in solids. At a particular temperature and pressure the speed of sound in air is always the same. The idea of finite speed of sound is obvious from the fact that the smoke of a gun fired at a distance is seen before the report of the gun is heard. Similarly, if we watch a wood-cutter, cutting a tree at some distance, we shall see the axe striking the tree first and the sound of the axe will be heard later on. In the play ground, when a race is started by a pistol shot, the persons standing at the other end of the track see the smoke of the pistol first and hear the sound later.

In the beginning the methods used to measure the speed of sound employed the measurement of time lapse between the flash of an explosion and arrival of its sound. In Fig 10.5 a gun is being fired at A. At a distance of about 8 kilometers at B on observing the flash, a stop watch is started. When report of the gun is heard, the watch is stopped. The time lapse between the two events is thus measured. On dividing the distance between A and B by this time interval, velocity of sound in air is calculated.

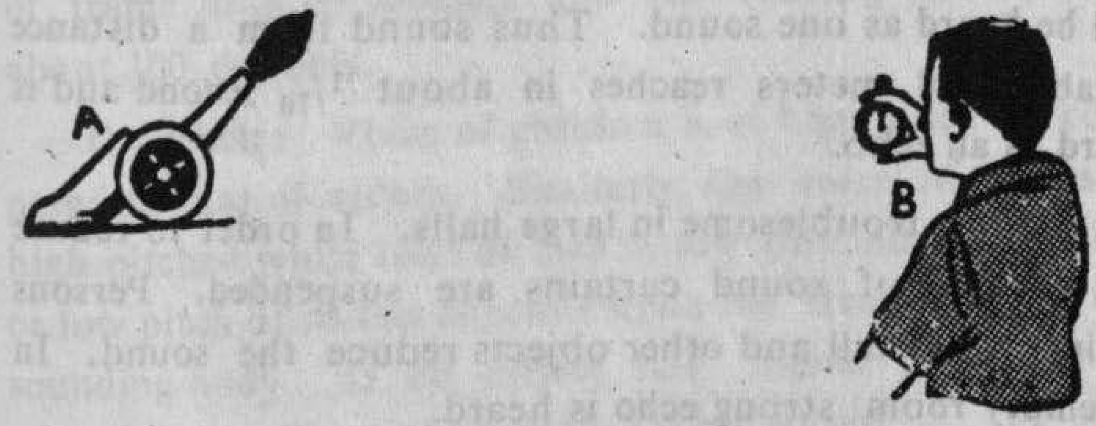


Fig. 10.5

10.3 Echo

Sound travels in the form of waves. Like light and heat waves the sound waves can also be reflected. Sometimes we hear echoes due to the reflection of sound.

You might have heard the sound of an echo in front of a huge building or in a big hall. This echo is the sound reflected from the walls.

At a distance of about 18 meters from a large building clap your hands or shout loudly. The sound reflected from the building, will be heard as an echo. Sounds reaching our ears after an interval of $^1/_{10}$ second or more are heard separately. If two sounds reach our ears in a time less than this interval of $^1/_{10}$ second they will merge together and will be heard as one sound. Thus sound from a distance of about 18 meters reaches in about $^1/_{10}$ second and is heard as an echo.

Echo is troublesome in large halls. In order to reduce the reflection of sound curtains are suspended. Persons sitting in the hall and other objects reduce the sound. In an empty room strong echo is heard.

After the flash of lightning, the roaring sound is due to successive reflections of sound between mountains, earth and the clouds.

10.4 Characteristics of Sound

We hear sounds of different types. These sounds differ from each other in the following characteristics :—

(a) Intensity or loudness.

(b) Pitch.

(c) Quality or timber.

We shall discuss these one by one.

(a) **Intensity :** Some body can produce loud or low sounds. Sometimes we whisper and at other times we even shout. The loudness of sound depends upon the *amplitude* of vibration of the sounding body. Thus when the drum is beaten hard, its mêmbrane vibrates with greater amplitude and loud sound is produced.

The intensity of sound is measured in *decibels.* Whisper is 10 to 20 decibels, loud talk 60 decibels, noise of traffic 70 to 80 decibels and the roaring of clouds is about 100 decibels.

(b) **Pitch :** Voice of children is of high pitch as compared to that of elders. Similarly, the voice of ladies is high pitched while that of men is low pitched. The high or low pitch of sound depends upon the frequency of the sounding body. If an object has higher frequency of vibration, it will produce high pitched sound.

Experiment

Mount your bicycle on its stand and rotate its wheel. Touch the spokes of the rotating wheel with piece of card board. It will produce sound. On increasing the speed of rotation the pitch of sound produced will also go on rising.

In the beginning when the wheel rotates slowly the tickling sound is produced. On increasing the speed of rotation this sound will become continuous. At still higher speed the pitch of sound increases.

Our ears can hear sounds of frequencies between 20 per second to 20,000 per second.

(c) **Quality :** We can distinguish between the sounds of different persons. We can also associate a particular sound to its source. If two persons are talking with the same intensity and pitch, we can still distinguish between their voices. This difference between the sounds is due to the quality of these sounds.

Most of the sounding objects do not produce sound of only one frequency. Besides the fundamental frequency sounds of twice, thrice four times etc., of this frequency are also produced by the sounding body. Each frequency has sound of different pitch. The quality of sound depends upon the number of higher frequencies present in the sound and their intensity. This is the reason why different people have voices which differ from each other. Similarly, sounds of different objects can be distinguished.

10.5 Musical Sounds and Noise

Sound reaches our ears in the form of waves. If these waves are regular, and continuous i.e., if the sounding object is vibrating regularly, the sound will produce pleasing effect upon the ears. On the other hand if the sound is irregular, discontinuous and is produced for short duration, it will not produce pleasing effect upon the ears.

Pleasing sounds are called *musical sounds*, and displeasing sounds are known as *noise*. Firing of gun, beating of hammer, traffic sound, sounds of factories, roaring of clouds are examples of noise. On the other hand all such sounds which produce pleasing effect upon your ears are musical sounds.

10.6 How do we hear

We hear sounds by our ears. The ear consists of three parts.

(i) outer ear (ii) middle ear and (iii) inner ear.

(a) **The Outer Ear:** The outer ear which is the visible part of the ear collects the sound waves and conducts them to the middle ear through a tube. At the inner end of this tube is the ear drum which vibrates with the sound waves.

(b) **The Middle Ear:** From the ear-drum middle ear starts. This part consists of three bones connected together. The first bone which touches the ear-drum is called *hammer*, the second is the *anvil* and the third is *stirrup*. These three bones connect the ear-drum to the inner ear and act like levers. Thus when the ear-drum vibrates, these bones transmit the vibrations to the inner ear. At the bottom of the middle ear there is a tube called *eustachian tube* which connects this part of the ear to the back of mouth.

This keeps equal pressure on both sides of the ear-drum.

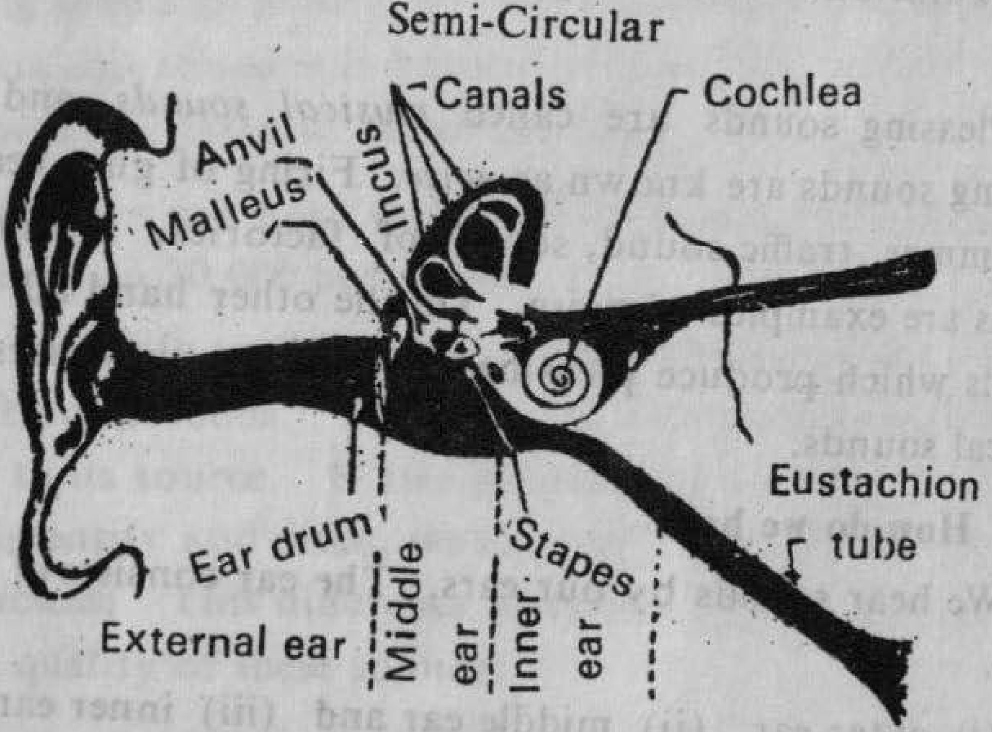

Semi-Circular
Canals
Cochlea
Anvil
Malleus
Incus
Eustachion
tube
Ear drum
Stapes
External ear
Middle
ear
Inner
ear

Fig 10.6

(c) **The Inner Ear :** The inner ear is snail shaped coiled tube called *cochlea*. This is filled with a fluid. The nerves which receive the sensation of sound, end here. When the ear-drum vibrates, the fluid in the cochlea transmits pressure differences to these nerve-endings. Thus sensation of sound reaches the brain.

There are three semi-circular canals placed in three different positions These are also filled with fluid. These help us in keeping our balance.

Two ears help us to determine the direction of sound. Certain animals like hare and horse are able to determine the direction of sound more precisely by twisting their ears.

10.7 How do we speak

Since all types of sounds are produced by vibrations, therefore, there must be some vibrating object inside our mouth with which we produce sound. Air coming from the lungs passes up through the *wind pipe.* Over the wind-pipe there is *larynx*. You can feel your larynx by touching below the chin and by trying to swallow. The larynx will move up and down.

The larynx has two elastic strips of tissue stretched across the top. These are the *vocal cords*. These are set into vibrations by the air coming out of the lungs. Thus sound is produced.

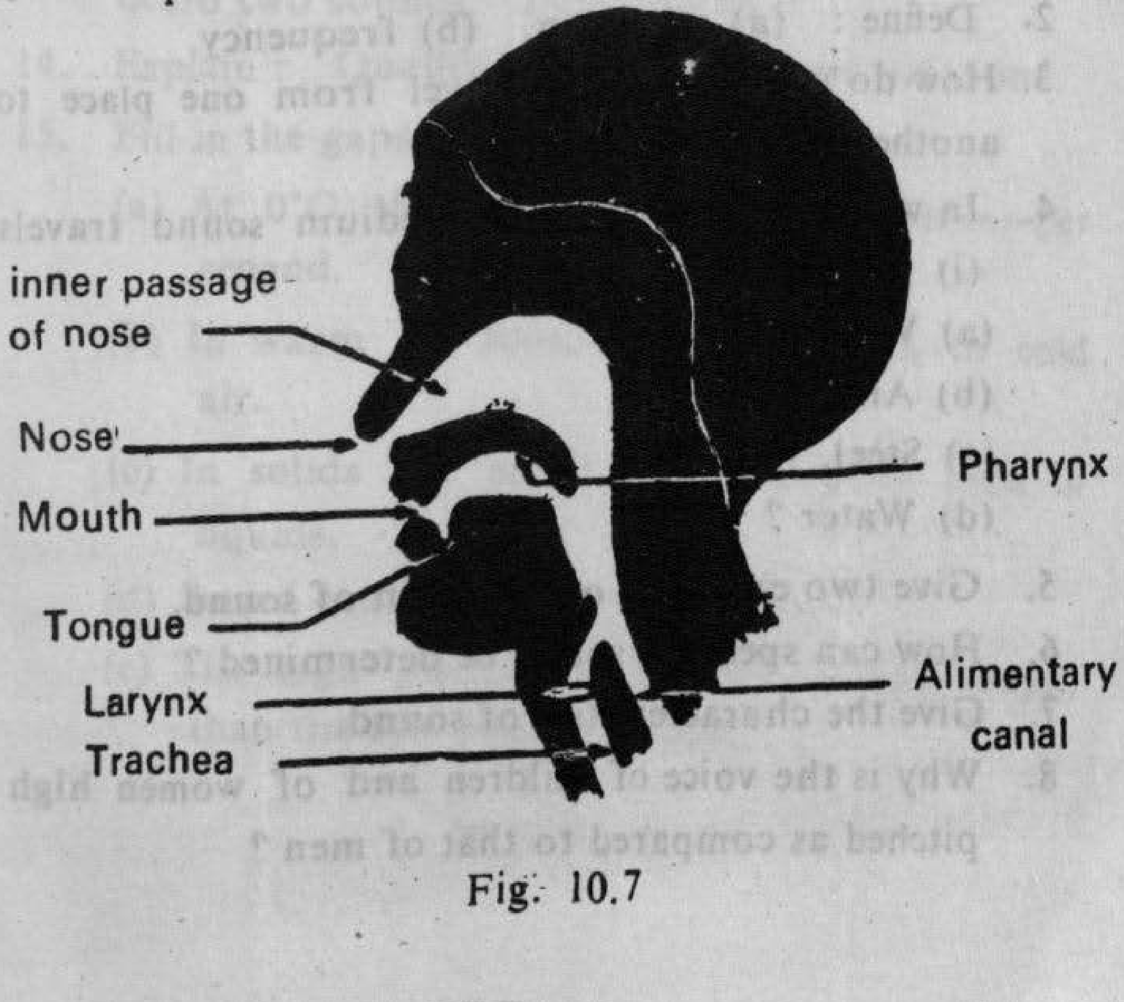

inner passage of nose
Nose
Mouth
Tongue
Larynx
Trachea
Pharynx
Alimentary canal

Fig. 10.7

The vocal cords can be stretched or released at will. This changes the pitch of sound produced. The intensity of sound produced depends upon the force with which air passes through the vocal cords.

The vocal cords of men are longer and thicker than those of women. Therefore, the sound of women is high pitched.

The quality of sound depends upon the construction of vocal cords, the cavities in the mouth, nose etc., and on the shape of tongue and the teeth.

Questions

1. How sound is produced ?
2. Define : (a) vibration. (b) frequency.
3. How do waves of sound travel from one place to another ?
4. In which of the following medium sound travels (i) fastest and (ii) slowest :—
   (a) Vacuum.
   (b) Air.
   (c) Steel.
   (d) Water ?
5. Give two examples of reflection of sound.
6. How can speed of sound be determined ?
7. Give the characteristics of sound.
8. Why is the voice of children and of women high pitched as compared to that of men ?

9. What is the difference between musical sound and noise ?
10. How do we speak ? Illustrate your answer with appropriate diagram.
11. Draw a figure of human ear and describe its different parts.
12. Explain with examples that the sound travels through solids, liquids and gases.
13. A boy was listening by applying his ear to a railway line. Another boy struck the line with a stone at some distance from him. The first boy heard two sounds. Explain why ?
14. Explain : Quality, pitch and intensity of sound.
15. Fill in the gaps :
    (a) At 0°C the speed of sound in air is——per second.
    (b) In warm air sound travels——than in cold air.
    (c) In solids the speed of sound is——than in liquids.
    (d) Sound cannot travel through——.
    (e) The high pitched sound has——wave-length than the low-pitched sound.

11

Electric Current

11.1 Electric Current

You know that all substances are made of atoms which have a complicated structure. Each atom has a central core called *nucleus* which carries a positive charge. Much lighter particles called *electrons* revolve around the nucleus in different orbits. Electrons are negatively charged particles. As the nucleus and the electrons revolving around it carry opposite types of charges, there exists a force of attraction between them. This force of attraction keeps the electrons in their orbits around the nucleus. The above mentioned description is of an isolated atom. In metals the atoms are situated so close to one another that the nucleus of one atom can affect the electrons in outer most orbit of the neighbouring atom. Therefore, the electrons in the outermost orbits of atom can move from one atom to the other inside the metal. These electrons are called the *free* or *conduction electrons*. Fig. 11.1 shows the different charges inside a metal. Black areas with positive signs indicate the nucleus of different atoms. The circles around these areas show the orbits of those electrons which do not leave their nuclei ordinarily. Gray shade in the intervening space indicate the free electrons which can be associated with any atom in the metal. The motion of free electrons inside a metal is like the motion of the molecules of a gas.

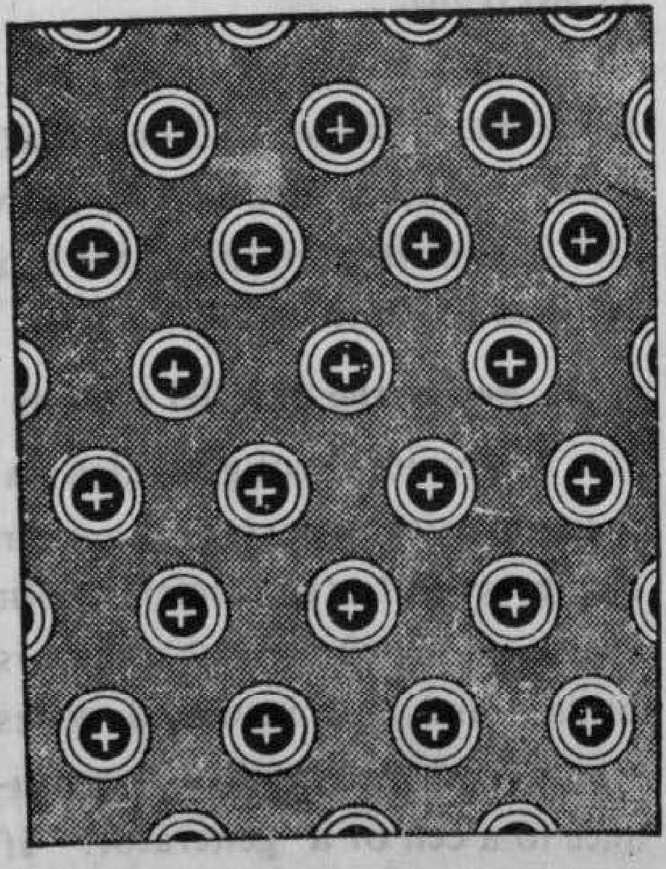


Fig. 11.1

When the ends of a metallic wire are connected to the two electrodes of a cell, the free electrons begin to drift from one to other end of the wire. The flow of electrons through the wire is known as *electric current*. As like charges repel and unlike charges attract each other, therefore free electrons move in the wire from the negative to the positive electrode of the cell. The direction of the electric current is indicated by the direction of the motion of electrons.

You already know that the path of an electric current is known as *circuit*. Circuits may be simple as well as complex. Complex circuits are of two types (i) *series circuit* and (ii) *parallel circuit*. We shall now discuss the characteristics of these circuits.

11.2 Series and parallel circuits

A circuit, through which an electric current passes, has three important parts : (i) a source of energy e.g., a cell or a generator, (ii) electric appliances such as electric bulb, heater, in which electric energy is utilised and (iii) insulated wires which connects the electric appliance to a cell or a generator. If only one electric appliance such as electric bulb is used in a circuit, such a circuit is called a simple circuit.

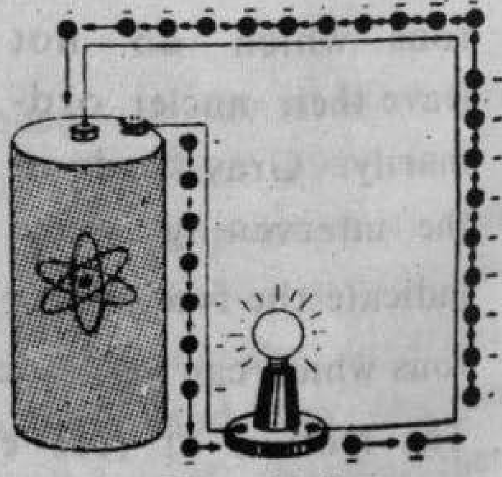


Fig. 11.2

If two or more than two bulbs are to be connected to a cell, there are two methods of connecting the bulbs to the cell, one is called the series connection and the other is known as parallel connection. We will now see the advantages of connecting a number of bulbs in series and in parallel.

Fig 11.3 shows three bulbs connected to a cell in series. One electrode of the cell is connected to one screw of the holder of the first bulb. The second screw of this bulb holder is connected to the first screw of the second bulb-holder which is connected to the third bulb-holder in the same manner. The last screw of the third holder is then connected to the second electrode of the cell. In this way the three bulbs are connected in series with the cell.

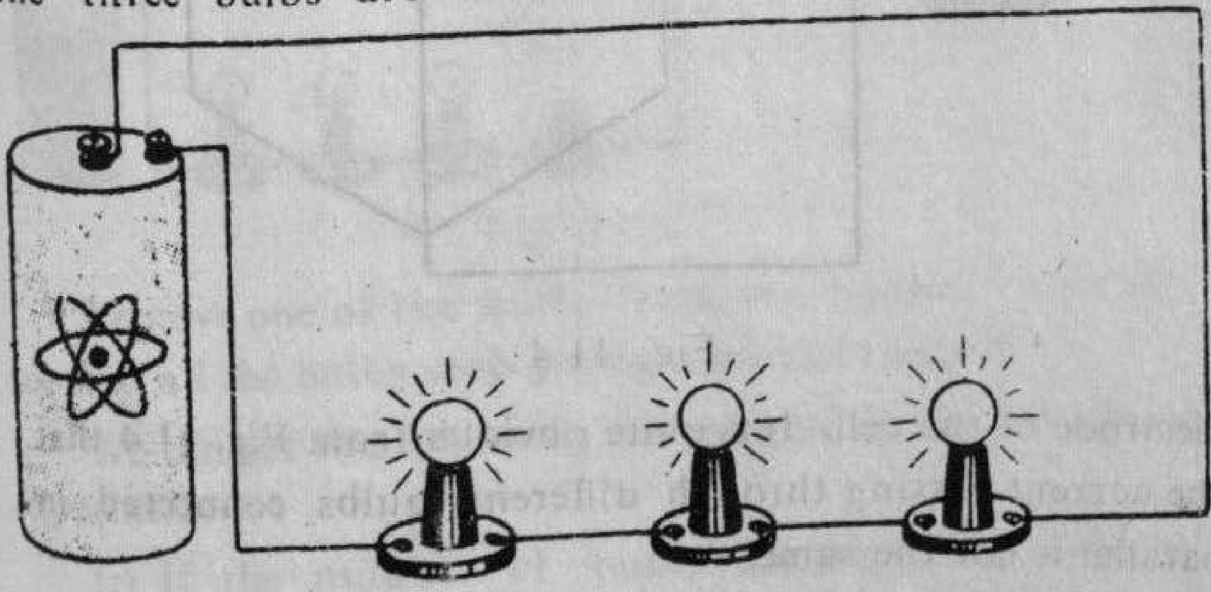


Fig. 11.3

Same current passes through all the three bulbs connected in series.

All the bulbs will be lighted. It is quite clear from Fig. 11.3 that same current flows through all the bulbs connected in series.

Fig. 11.4. shows three bulbs connected in parallel with a dry cell. In such a connection one screw of each bulb holder is connected to one electrode of the cell. The second screw of each bulb is connected to the other

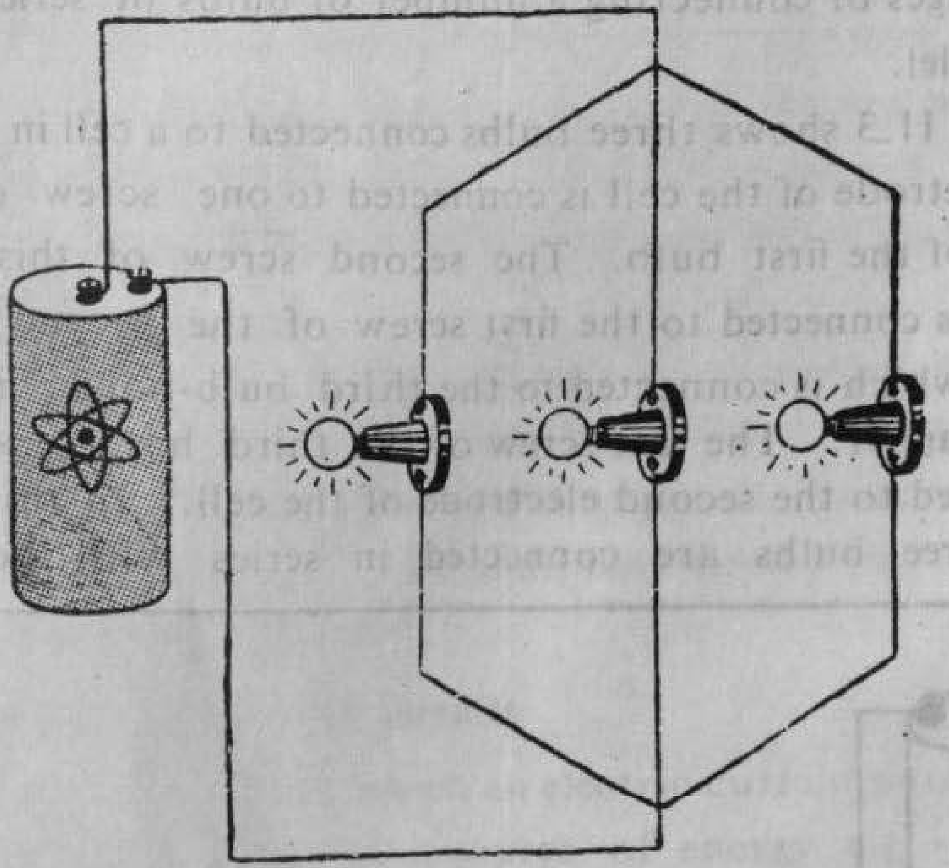


Fig. 11.4

electrode of the cell. It is quite obvious from Fig. 11.4 that the current passing through different bulbs connected in parallel is not the same.

11.3 Advantages of series and parallel circuits

We will perform some experiments using series and parallel connections of bulbs and will study their comparative usefulness.

Experiment

Connect two bulbs in series with a dry cell and estimate the light given by the bulb. Now connect two more bulbs in series with the same circuit. You will see that the light emitted by each of the four bulbs decreases.

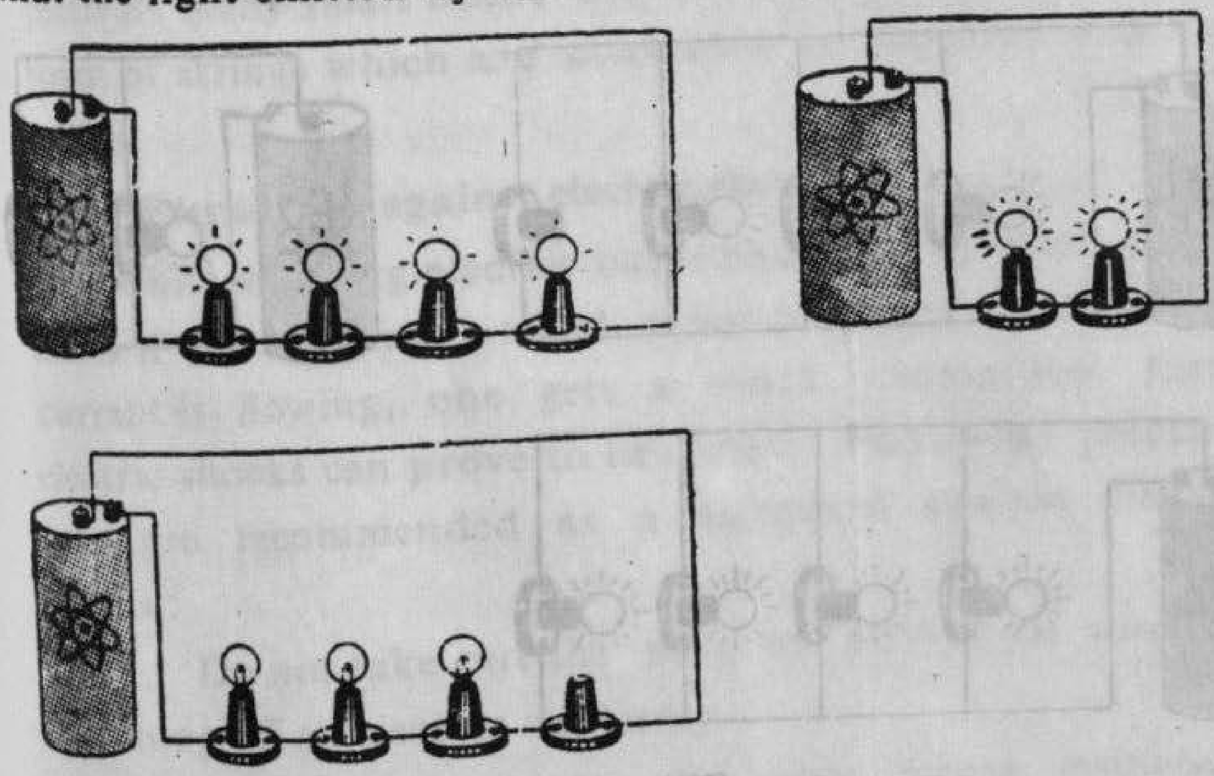


Fig. 11.5

Remove one of the bulbs from its holder. You will see that all the bulbs stop giving out light (why ?)

We can get the following conclusions from the above experiment :

(i) If the number of bulbs connected in series is increased, the light emitted by them will decrease.

(ii) If one of the bulbs connected in series gets fused, the current passing through all of them will stop and they will stop emitting light.

Now repeat the above experiment by first connecting two bulbs in parallel with a dry cell. Estimate the light emitted by them. Connect two more bulbs in parallel with same circuit. Light emitted by all the bulbs will not be affected. Moreover, if one of the bulbs gets fused or is removed from its holder, the rest of the bulbs will continue giving out light as before (Fig 11.6).

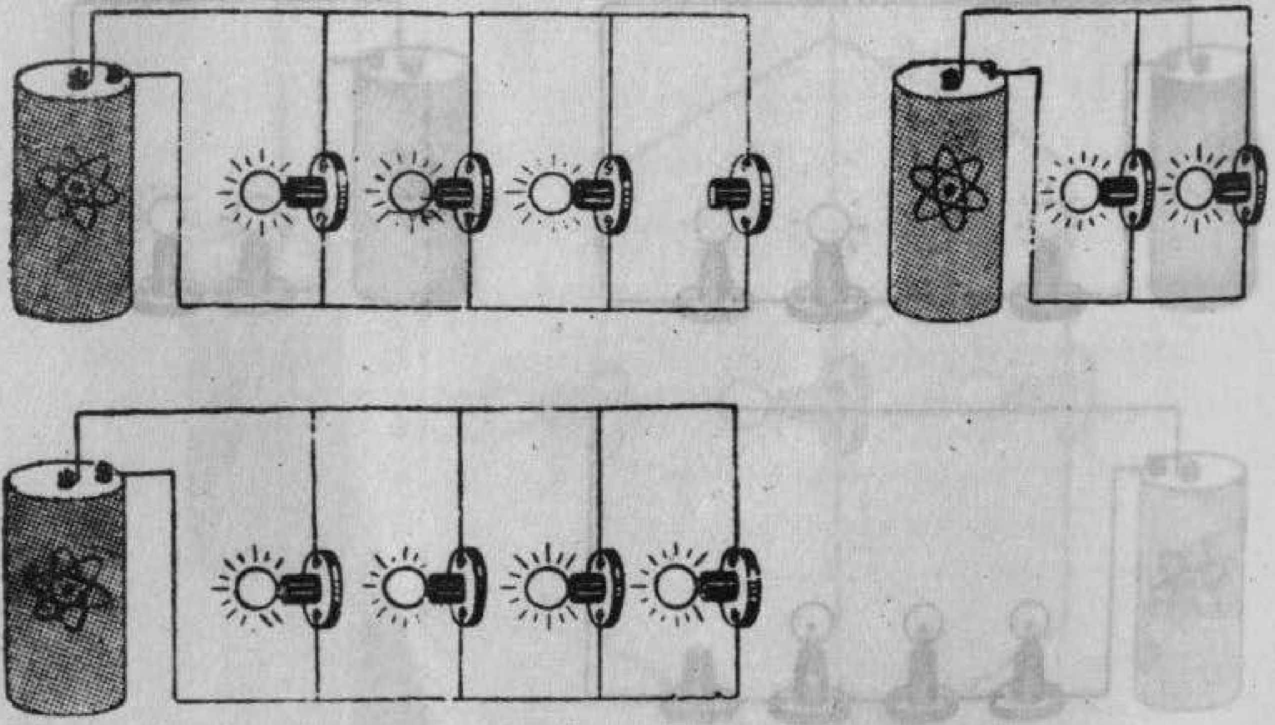


Fig. 11.6

We can conclude from the second part of the experiment that (i) if the number of bulbs connected in parallel is increased, the light emitted by them is not affected and (ii) if one of the bulbs is removed, the rest will continue to emit light.

We can now easily decide about the method of connecting the bulbs in our houses. If all the bulbs in a house are connected in series and the bulb in one of the rooms is switched off, then bulbs of all other rooms will stop emitting light.

While arranging temporary electric lighting during festivals many small bulbs are connected in series in the form of strings which are connected in parallel with the mains.

11.4 Precautions against electric shocks

While handling electric bulbs and other electric appliances if one happens to touch a part of the circuit in which current is flowing, one gets a shock. Sometimes these electric shocks can prove to be fatal. Following precautions are recommended as a safeguard against electric shocks :

1. Do not take out the plug by pulling its wire for switching off an electric appliance.

2. Immediately change the wires whose insulation has been worn out.

3. Wires connecting the electric appliances with the main should not be thrown on the floor carelessly. They may sometimes cause an electric shock if stepped upon.

4. Do not take out the plug from the socket while standing on a wet ground. In these conditions the shock is often fatal.

5. Do not connect many electric applicances to the same socket.

6. Always use electric appliances made by reliable companies.

7. The main switch should be switched off while repairing any part of the circuit in your house. If it is not possible, then stand on wooden plank or chair or wear rubber gloves while doing such a repair work.

8. Switch off the electric appliances after use if they are not automatic.

9. Do not climb the electric poles on the roadside.

10. Do not touch the wires if they fall down from the electric poles. In such an event inform the electricity department.

11. Do not touch electric poles during or immediately after the rain fall.

11.4 Different methods of producting Electric Current

You have studied different methods of producing electric current. Usually chemical and mechanical methods are used for producing electric current on commercial scale. Cells such as voltaic cell, dry cell and storage cell produce electric current, by chemical method while generators produce electric current by mechanical method. We will now consider these methods in detail.

(*i*) Voltaic Cell

A voltaic cell consists of copper plate, a zinc plate and dilute sulphuric acid. Copper and zinc plates are placed in a glass vessel containing dilute sulphuric acid in such a manner that they should not touch each other. These plates are known as *electrodes* and diulte sulphuric acid is called the *electrolyte.*

In chapter 6 you have studied that some compounds are dissociated into positive and negative ions when they are dissolved in water. When sulphuric acid (H_2SO_4) is dissolved in water, $2H^+$ and SO_4^{--} ions are produced. During this process SO_4^{--} ion gets two extra electrons and so it is negatively charged. Hydrogen ion ($2H^+$) loses two electrons and so it is positively charged. The above mentioned process of dissociation is represented by the following equation.

$$H_2SO_4 \rightarrow 2H^+ + SO_4^{--}$$

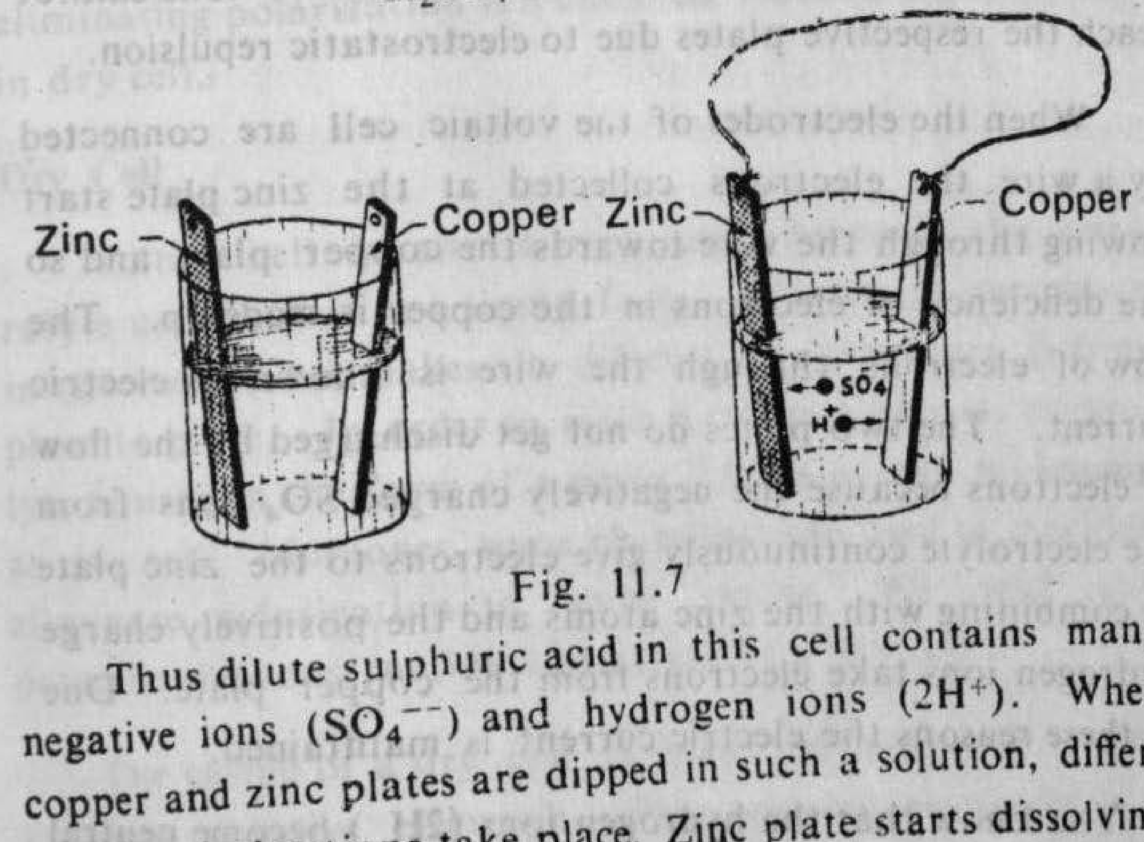


Fig. 11.7

Thus dilute sulphuric acid in this cell contains many negative ions (SO_4^{--}) and hydrogen ions ($2H^+$). When copper and zinc plates are dipped in such a solution, different chemical actions take place. Zinc plate starts dissolving in the dilute sulphuric acid. While going into the solution of sulphuric acid the zinc atoms combine with SO_4^{--}ions present in dilute sulphuric acid to form $ZnSO_4$ molecules, The two extra electrons of SO_4 ions are handed over to the zinc plate which acquires negative charge.

Hydrogen ions (2H) go towards the copper plate ; get two electrons from it and change into neutral hydrogen molecules. By this process the copper plate is charged positively because it loses electrons. Neutral hydrogen molecules collect around the copper plate in the form of tiny bubbles. These reactions continue within the cell till the plates collect so much charge that more ions cannot reach the respective plates due to electrostatic repulsion.

When the electrodes of the voltaic cell are connected by a wire. the electrons collected at the zinc plate start flowing through the wire towards the copper plate and so the deficiency of electrons in the copper is made up. The flow of electrons through the wire is known as electric current. The two plates do not get discharged by the flow of electrons because the negatively charged SO_4 ions from the electrolyte continuously give electrons to the zinc plate by combining with the zinc atoms and the positively charge hydrogen ions take electrons from the copper plate. Due to these reasons the electric current is maintained.

You know that the hydrogen ions $(2H^{+})$ become neutral after getting electrons from the copper plate and collect around it in the form of bubbles. After getting current from the voltaic cell for a short time, the number of hydrogen bubbles collected at the copper plate is so huge that they form a layer of hydrogen gas around the copper plate. As hydrogen is a non-conductor of electricity, therefore hydrogen ions from the electrolyte cannot pass through the layer of hydrogen gas around the copper plate and soon the electric current supplied by the cell decreases. Thus defect of the voltaic cell is called *polarization*. One of the methods to remove this defect is to take out the copper plate from the cell and clean it with a brush. Another method of eliminating polarization is a chemical method which is used in dry cell.

Dry Cell

Voltaic cell is also a wet cell because the electrolyte used in it is in a liquid form. The liquid electrolyte in the voltaic cell makes it difficult to transport it from place to place. In order to make a cell portable its electrolyte is used in the form of a paste. Such a cell is known as dry cell. Moreover, some chemicals are used in it which eliminate polarization to some extent. We will now describe the construction and action of a dry cell.

The casing of a dry cell is made of zinc and it also acts as a negative electrode. The positive electrode is a carbon rod and it is present in the centre of the cylindrical zinc casing. The space between the carbon rod and

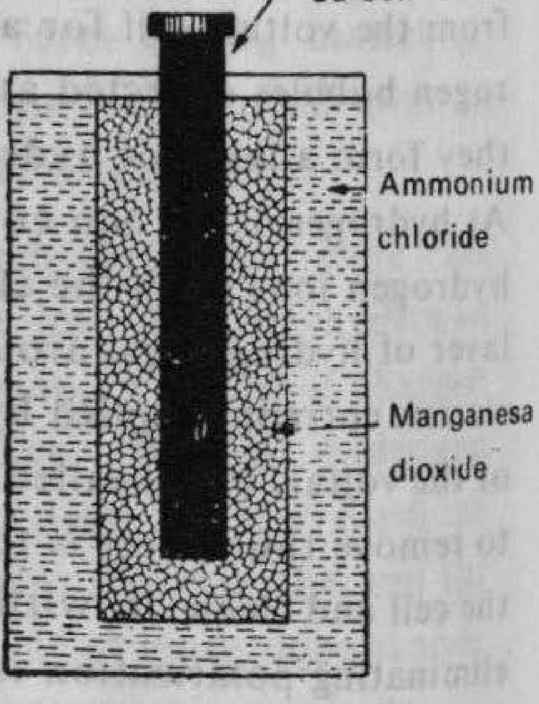


Fig. 11.8

the zinc casing is filled with manganese dioxide and paste of ammonium chloride as shown in Fig. 11.8. The cell is then sealed with lac to prevent the ammonium chloride paste from drying. The action of ammonium chloride is similar to the action of dilute sulphuric acid in voltaic cell *i.e.*, current is produced by the mutual action of ammonium chloride paste and the two electrodes. Manganese dioxide helps in eliminating polarization to a large extent and so the cell can give current at a constant rate, but after some time the current decreases. However, if the cell is allowed to remain unused for some time, is starts giving current as before.

11.5 Direct current (DC) and alternating current (AC)

If the electrodes of an electric cell are connected by a wire, electrons begin to flow through the wire from the negative to the positive electrode. The flow of electron is known as electric current. In this case the direction and the magnitude of the current remain constant. Such a current does not change with time and it is known as a *direct current*.

However, there is a type of machine which generates such an electric current which changes its direction many times in one second. Such a current is known as alternating current which flows through a wire in one direction for a small interval of time and then flows in the opposite direction for the same interval. This process is repeated many times in one second. When an alternating current starts flowing in one direction, changes its direction and then starts flowing in the original direction, it is said to complete one *cycle*.

The number of cycles completed by an alternating current is known as its *frequency*.

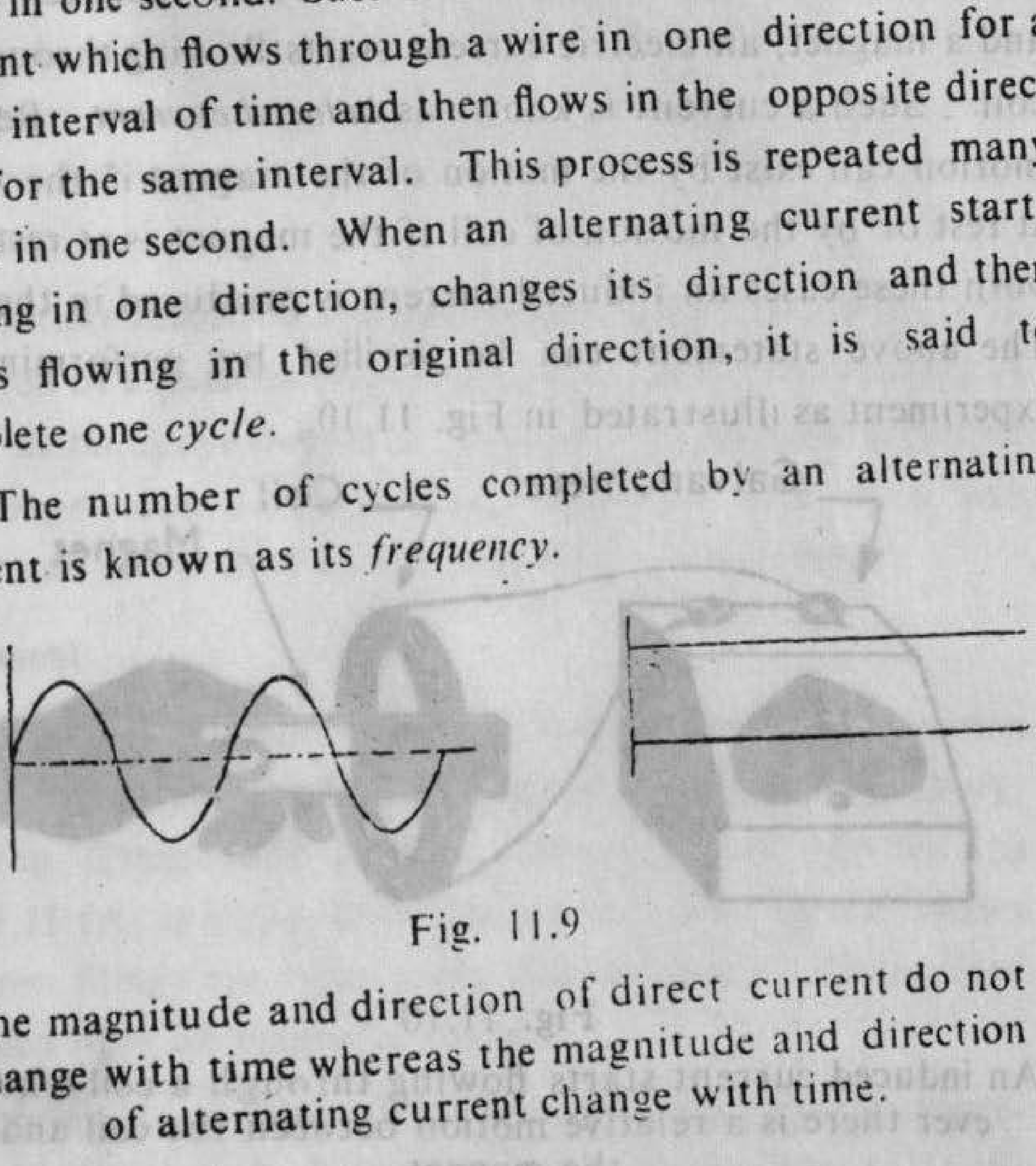


Fig. 11.9

The magnitude and direction of direct current do not change with time whereas the magnitude and direction of alternating current change with time.

11.6 Generators

Now we shall consider the construction of machines which converts mechanical energy into electrical energy. The machines are called *generators*. A type of these machines generates alternating current and it is called A.C generator or alternator. You have already considered the principle of generators in 7th class. It is only reviewed briefly here.

Whenever there is a relative motion between a coil and a magnet, an electric current starts flowing through the coil. Such a current is known as *induced current*. Relative motion can exist by the motion of the magnet if the coil is at rest or by the motion of coil if the magnet is at rest. In both these cases an induced current is produced in the coil. The above statement can be verified by performing an experiment as illustrated in Fig. 11.10.

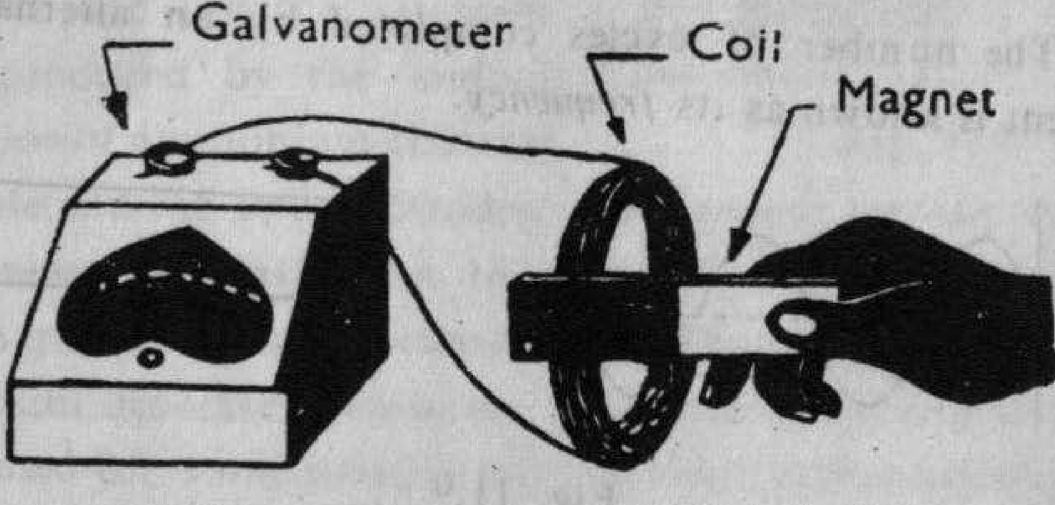


Fig. 11.10
An induced current starts flowing through a coil where-ever there is a relative motion between the coil and the magnet.

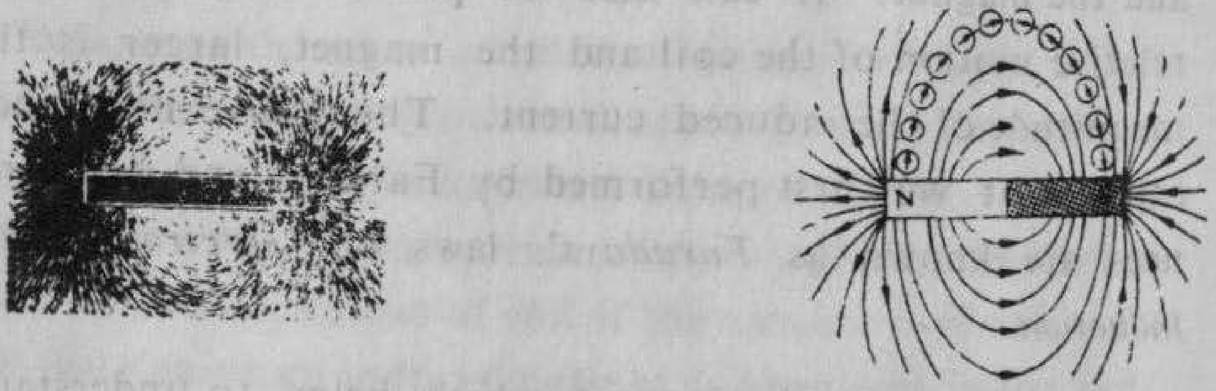
If the magnet is moved in or out of the coil, the galvanometer shows a deflection. The same result can be obtained if the magnet is kept stationary and the coil is moved over it. This experiment shows that an induced current is produced in the coil by the relative motion of the coil and the magnet. The induced current continues to flow as long as there is a relative motion between the coil and the magnet. It can also be proved that faster the relative motion of the coil and the magnet, larger is the magnitude of the induced current. The above mentioned experiment was first performed by Faraday and its inferences are known as *Faradays'* laws of *electromagnetic induction.*

Another scientific concept which helps to understand the action of a generator is that of magnetic field which is defined as *the space around a magnet in which the influence of the magnet can be felt.* The magnetic field of a bar magnet can be studied by the following experiment.

Experiment

Place a glass sheet over a bar magnet and sprinkle iron filings on the glass sheet. Tap the glass sheet gently. The iron filings will arrange themselves as shown in Fig. 11.11 (A) A close examination of this figure shows that iron filings are lying along distinct lines. These lines are called lines of magnetic force.

The magnetic fields of bar magnets are usually represented by drawing the lines of magnetic force Fig. 11.11 (B) shows the magnetic field of a bar magnet by drawing lines of magnetic force by means of a compass needle. Every line of magnetic force starts from the north pole of the magnet and proceeds towards the south pole. The strength of a magnetic field can also be represented by drawing the lines of magnetic force properly. The lines of magnetic



A Fig. 11.11 B

The magnatic field of a bar magnet can be plotted either by the help of iron filings or by compass needle.

force crowd together where the magnetic field is stronger for example near the poles of a bar magnet and these lines spread out where the magnetic field is not so strong.

The magnetic field between two opposite poles is represented in Fig. 11.12.

Using the concepts of magnetic field and lines of magnetic force Faradays' laws of electromagnetic induction can be stated as follows.

1. Whenever the number of lines of magnetic force passing through a coil changes, an induced current is produced in the coil. The induced current lasts for a time while the number of lines of magnetic force passing through the coil change.

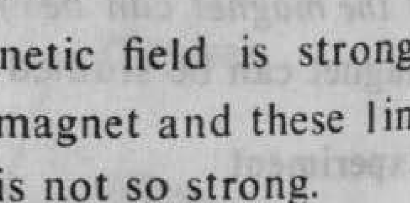


Fig. 11.12

2. The magnitude of the induced current is proportional to the rate of change of times of magnetic force passing through the coil.

In order to produce the current in a coil continuously the relative motion of the coil and the magnet should be maintained all the while. It is obvious that mechanical energy is needed for maintaining this relative motion and this mechanical energy is converted into electrical energy which is the principle of generators. Now we will describe two different types of generators.

First type of generator is illustrated in Fig. 11.13

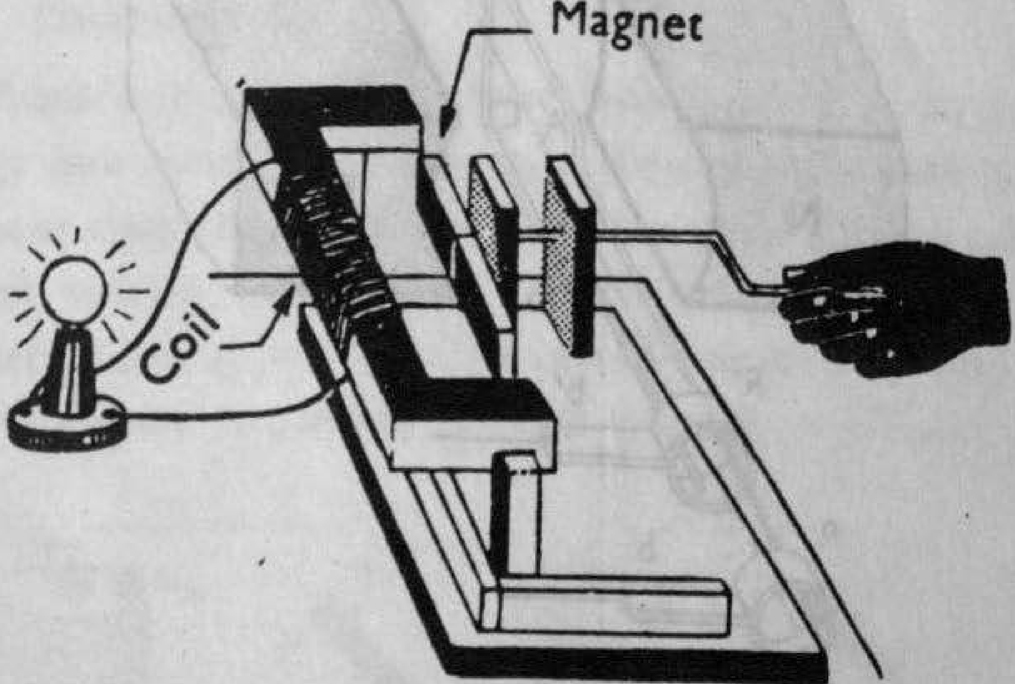


Fig. 11.13

Here the ends of the coil wound over an iron frame are connected to an electrict bulb. A bar magnet can be rotated in between the ends of the frame. When the bar magnet is rotated, the number of lines of magnetic force passing through the coil changes. An electric current starts flowing through the circuit and bulb is lit up. . If the bar magnet is rotated rapidly, the bulb glows brilliantly.

Second type of generator is illustrated in Fig. 11.14. A coil can rotate about its axis in the magnetic field between two opposite magnetic poles. The two ends of the coil are connected to two rings RR which rotate along

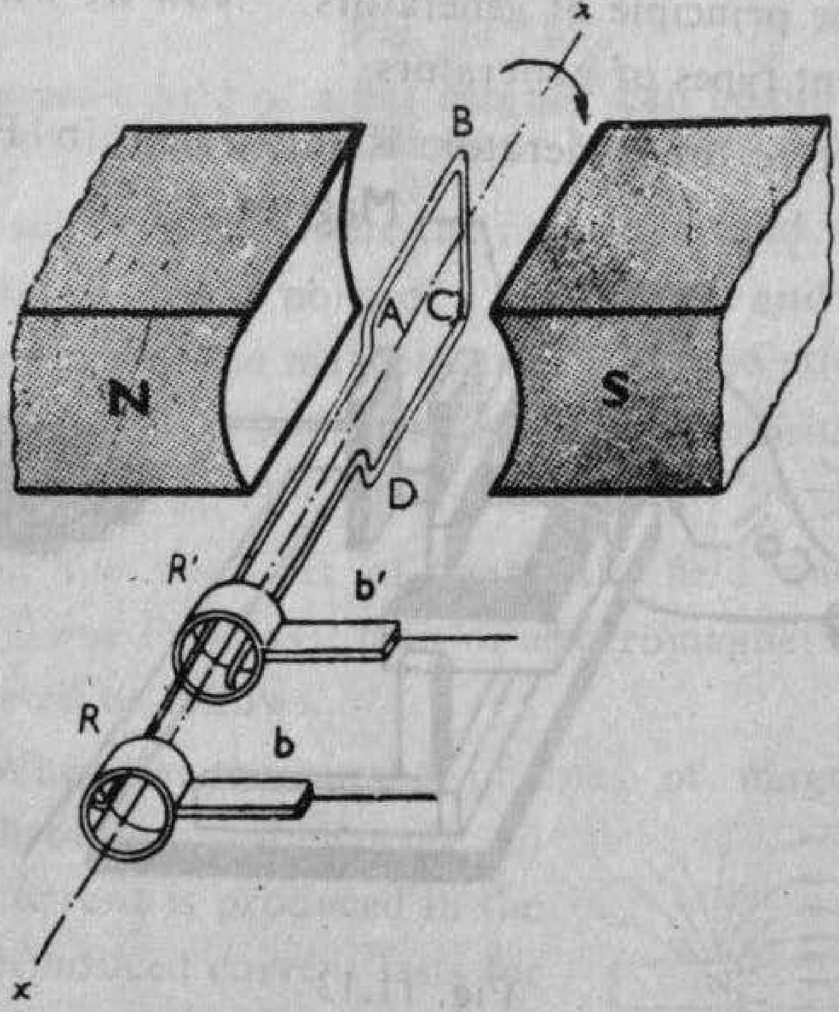


Fig. 11.14

with the coil. Two stationary carbon brushes b b can rub against the rings. When the coil is rotated, the number of lines of magnetic force passing through the coil change continuously and an induced current starts flowing through the coil. This current can be used in the external circuit via carbon brushes.

In the first type of generator described above the coil is stationary and the current is generated by motion of megnetic field. In the second model the magnetic field is stationary but the current is produced by the rotation of the coil. The current from both these generators is an alternating current.

11.7 Electric Motor

Electric motor is a machine which converts electrical energy into mechanical energy. You have studied in the previous class that all those machines which produce some sort of motion, contain one or more electromagnets. The magnetic force of an electromagnet remains only while an electric current is passing through it and it is proportional

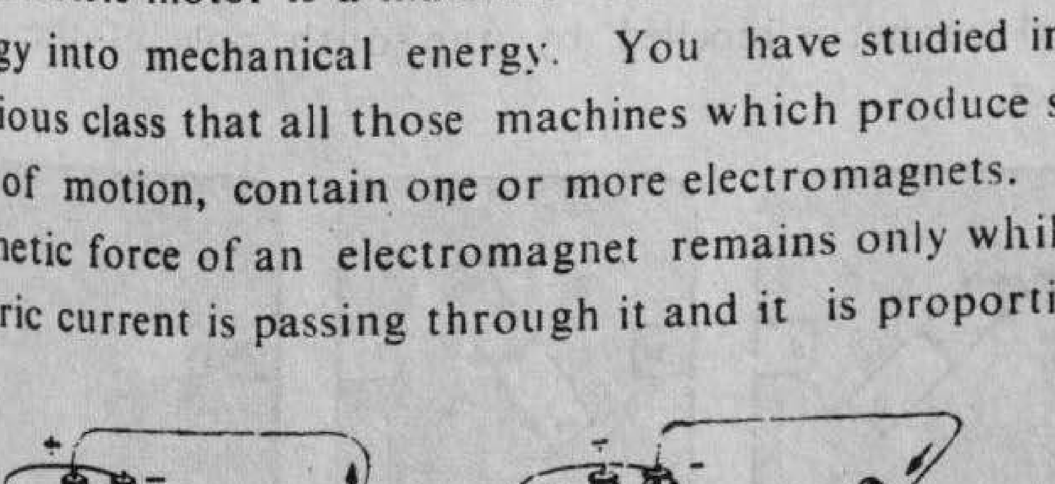


Fig. 11.15

to the number of turns of the wire and the current passing through it. Moreover, the polarity of its poles depends on the direction of the current flowing through it. If the direction of the current is reversed, the end of the electromagnet which was previously a north pole, now becomes a south pole. This property of an electromagnet is very useful in an electromagnet.

We will now describe a model of an electric motor which is illustrated in Fig. 11.16. The central magnet can rotate about a horizontal axis and it is called an *armature*. Two stationary magnets are called *field magnets*. The north pole of the central magnet is repelled by the north pole of the field magnet. Similarly, the south pole of the central magnet is repelled by the south pole of the field magnet.

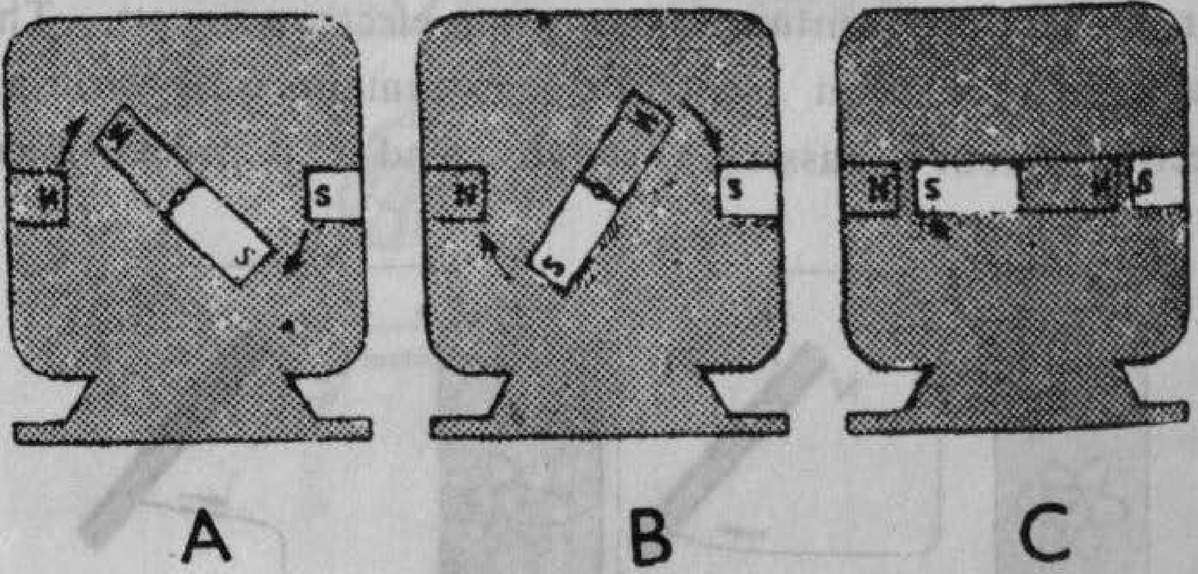


Fig. 11.16

Due to the repulsive forces, the central magnet begins to rotate. After quarter rotation the north pole of the central magnet is attracted by the south pole of the field magnet and the south pole of the field magnet is attracted by the north pole of the field magnet. Due to the attractive forces the central magnet continues to rotate further. When the central magnet completes half a rotation, the north pole of central magnet comes against the south pole of the field magnet and the south pole of the central magnet comes in front of the north pole of the field magnet. Due to the attractive forces the central magnet stops rotating and this simple electric motor stops working after completing half a rotation. Thus such a motor cannot work continuously. However, if the poles of the armature can be reversed after every half rotation, this motor can then work continuously. The poles of a bar magnet cannot be changed quickly but it is possible in the case of an electromagnet by only changing the direction of current passing through it.

Usually the armature of electric motors is an electromagnet and the device used to change the direction of the current through it is a *commutator*. The direction of the current through the armature of a motor is changed by means of the *commutator* at such suitable instants that the armature can rotate continuously. We will now consider a model of an electric motor which is illustrated in Fig. 11.17. The armature of this motor is made of a cork by winding 25 to 30 turns of insulated wire (SWG 24-26) in a groove around the cork. The two pins fixed in the opposite faces of the cork serve as an axis of rotation.

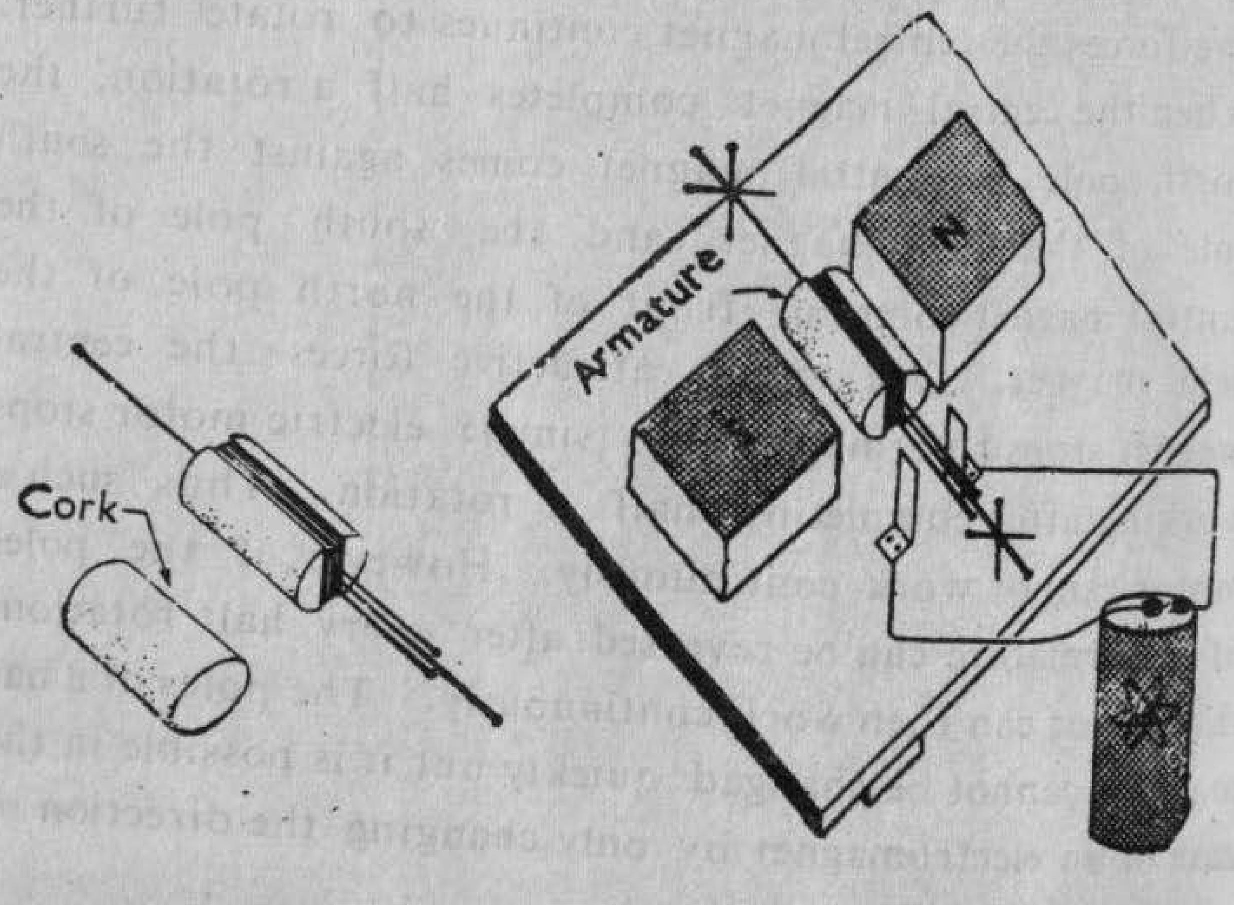


Fig. 11.17

The two ends of the coil wound around the cork are connected to the two pins fixed on one of its faces which serves as a *commutator*. The axle of the armature is supported on pins fixed on a drawing board. Two copper strips are fixed on the board in such a way that the pins fixed on the same face of the coil can touch the copper strips during rotation. Two opposite poles of two bar magnets are placed facing the armature.

When the two copper strips are connected to the terminals of a 6 V battery, the armature of the motor starts rotating. If the motor does not work, the armature may be given an initial push. The direction of the current passing through the armature changes the direction after each half rotation by means of *commutator* and the motor works continuously.

Questions

1. How current flows in a metallic conductor?
2. Which method of connection is preferred while connecting electric bulb in houses?
3. Explain the construction and action of a voltaic Cell ?
4. What do you mean by polarisation?
5. Differentiate between direct current and alternating current.
6. What is the difference between a generator and an electric motor ? Name the scientific principles used in these devices.
7. Fill up the blanks:
    (i) Electric current in a metallic conductor is a——.
    (ii) Voltaic cell converts chemical energy into——.
    (iii) Dry cell in fact is not——.

(iv) Direct current does not change in——and ——with time.

(v) The magnitude and direction of alternating current——with time.

(vi) The space around a magnet in which its influence can be felt is called a——.

(vii) The magnitude of the induced current in a coil depends on——of line of magnetic force passing through it.

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